Vandenberg Air Force Base, Space Launch Complex 3
Napa and Aldén Roads
Lompoc
Santa Barbara County
California

HAER No. CA-133-1

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Western Region
Department of the Interior
San Francisco, CA 94107

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HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 3 (SLC-3)

HAER No. CA-133-1

Location:	Napa and Alden Roads Lompoc Santa Barbara County California USGS 7.5 minute Surf, California Quadrangle Universal Transverse Mercator coordinates: 5.720900.3835900
Date of Construction:	1958-1959. Altered 1965, 1968, 1972, 1973, 1974, 1975, 1976, 1977, 1980.
Engineer:	Ralph M. Parsons
Builder:	Wells Benz, Inc.
Present Owner:	United States Air Force
Significance:	Space Launch Complex 3 (SLC-3) is one of the first operational installations in the United States military space program. The complex was constructed in 1959 to launch satellites into polar orbits without passing over inhabited areas. Since its first launch in 1960, SLC-3 has supported 101 launches of Atlas and Thor boosters carrying a variety of satellite payloads. SLC-3 played an important role in the United States' Cold War defense strategy by supporting surveillance and "early warning system" satellite programs throughout the 1960s and early 1970s. The complex consists of two launch pads, SLC-3 East and SLC-3 West. These pads contain two of the only three remaining A-frame service gantries (mobile service towers) characteristic of early Atlas launch pad construction. The pads are equipped with the only retractable umbilical masts at any U.S. space launch complex.
Report Prepared By:	Peter von Szilassy Carol DeLisle Suzanne Smidt Versar, Inc. 6850 Versar Center Springfield, Virginia 22151
Date:	March 1993

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

CHAPTER 1

INTRODUCTION

Space Launch Complex 3 (SLC-3) at Vandenberg Air Force Base was one of the first operational installations in the United States military space program. The complex was constructed in 1959 to launch satellites into polar orbits without passing over inhabited areas. Since its first launch in 1960, SLC-3 has supported 101 launches of Atlas and Thor boosters (delivery vehicles) carrying a variety of satellite payloads (space vehicles). SLC-3 played an important role in the United States' Cold War defense strategy by supporting surveillance satellite programs such as *Samos*, and "early warning system" satellite programs such as the Missile Defense Alarm System (*Midas*) throughout the 1960s and early 1970s. Since then, SLC-3 has supported other important military space programs such as the Defense Meteorological Satellite Program (*DMSP*), as well as several scientific programs. The scientific satellites launched from SLC-3 include *Seasat*, *Geosat*, and satellites for the Precision Recovery Including Maneuverable Entry (*PRIME*) program, whose data provided the foundation for development of the Space Shuttle.

SLC-3 is located on South Vandenberg Air Force Base approximately 50 miles west northwest of Santa Barbara, California (figs. 1.1, 1.2). The complex consists of two launch pads SLC-3 East (SLC-3E) and SLC-3 West (SLC-3W; fig. 1.3). These pads contain two of the only three remaining A-frame service gantries (mobile service towers) characteristic of early Atlas launch pad construction. The pads are equipped with the only retractable umbilical masts at any U.S. space launch complex. Other key structures associated with the launch pads include launch service buildings located directly beneath elevated concrete launch decks, deluge channels with retention basins used to direct and store cooling waters during launch, theodolite buildings used to house instrumentation to calibrate the delivery vehicle's inertial guidance system, and a common launch operations building that houses remote launch control and monitoring equipment, much of which is characteristic of early 1960s electronic technology. The pads have undergone several major modifications driven by the changing requirements of the payload programs and delivery vehicles to be launched from them. SLC-3E has been inactive since 1987. SLC-3W is still active and has launches scheduled through 1994.

The United States Air Force (USAF) plans to modify SLC-3 to accommodate heavier payloads launched aboard the Atlas II family of delivery vehicles. Planned modifications entail demolishing five structures on SLC-3E: the mobile service tower (MST), the umbilical mast, the Theodolite Shelter (Bldg. 788), the Entry Control Point (Bldg. 768), and a traffic check house (Bldg. 759). The A-frame MST at SLC-3E will be replaced with a C-frame gantry characteristic of more modern launch pad construction. SLC-3E's retractable umbilical mast will

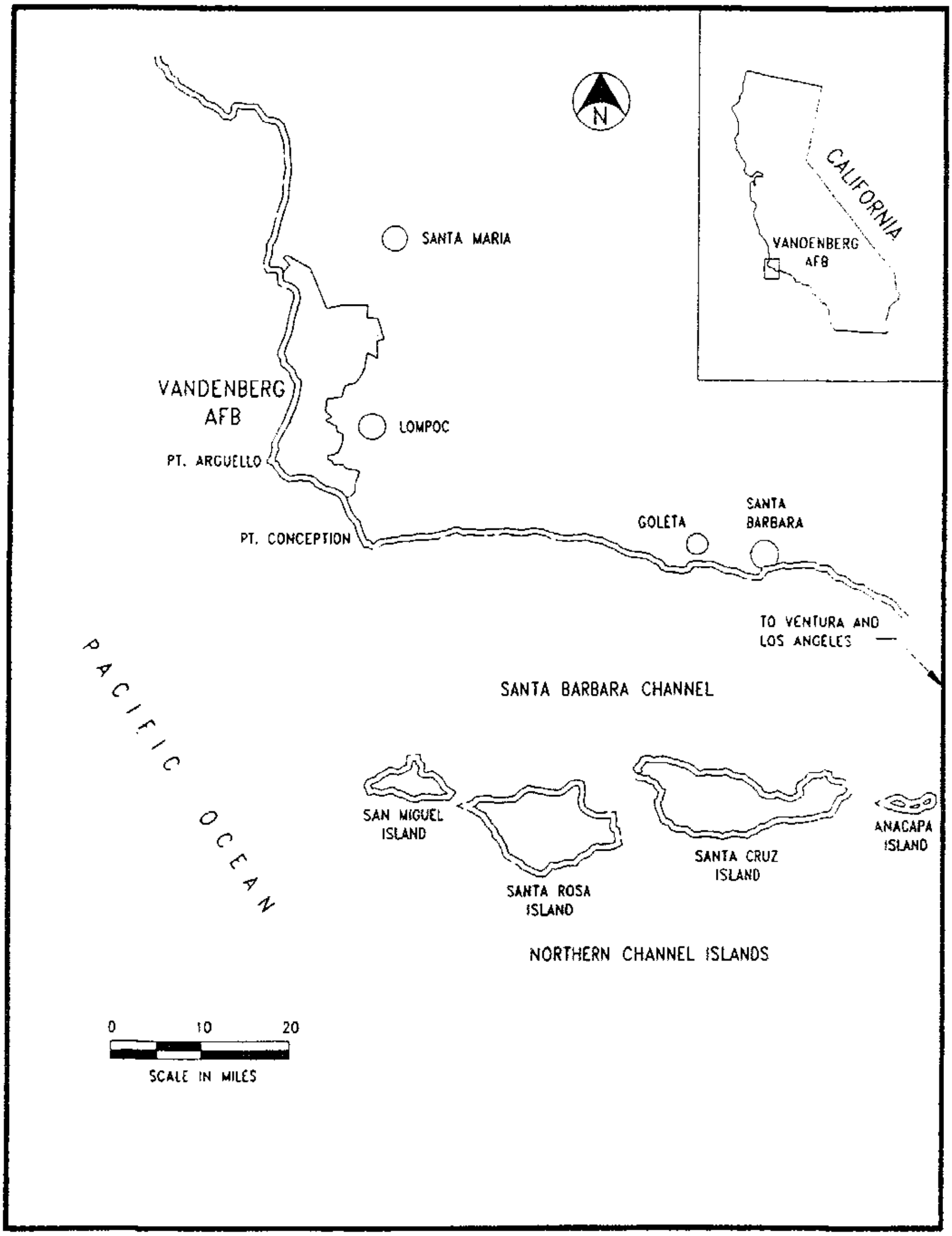


Fig. 1.1. Location of Vandenberg Air Force Base

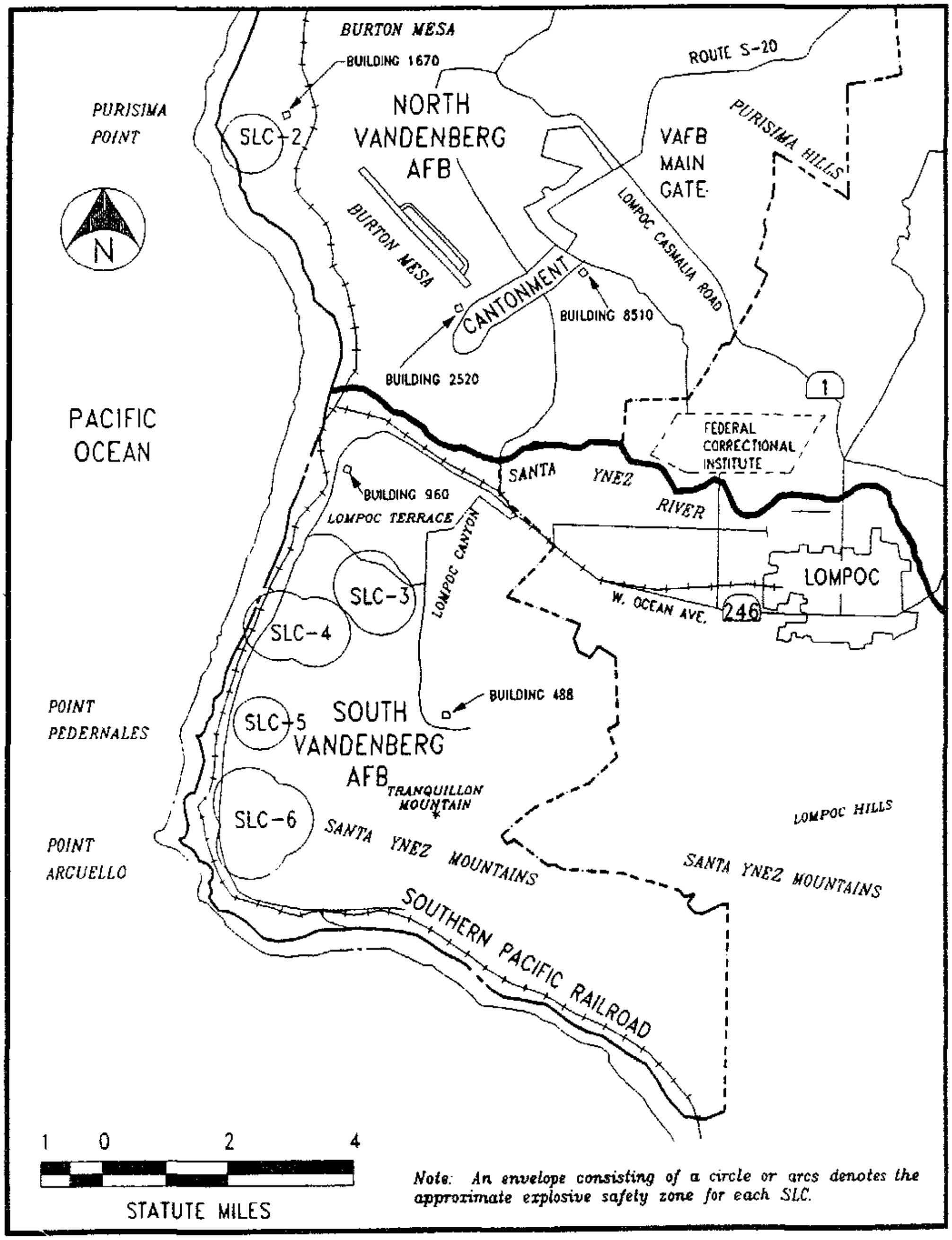


Fig. 1.2. Location of SLC-3 on South Vandenberg Air Force Base

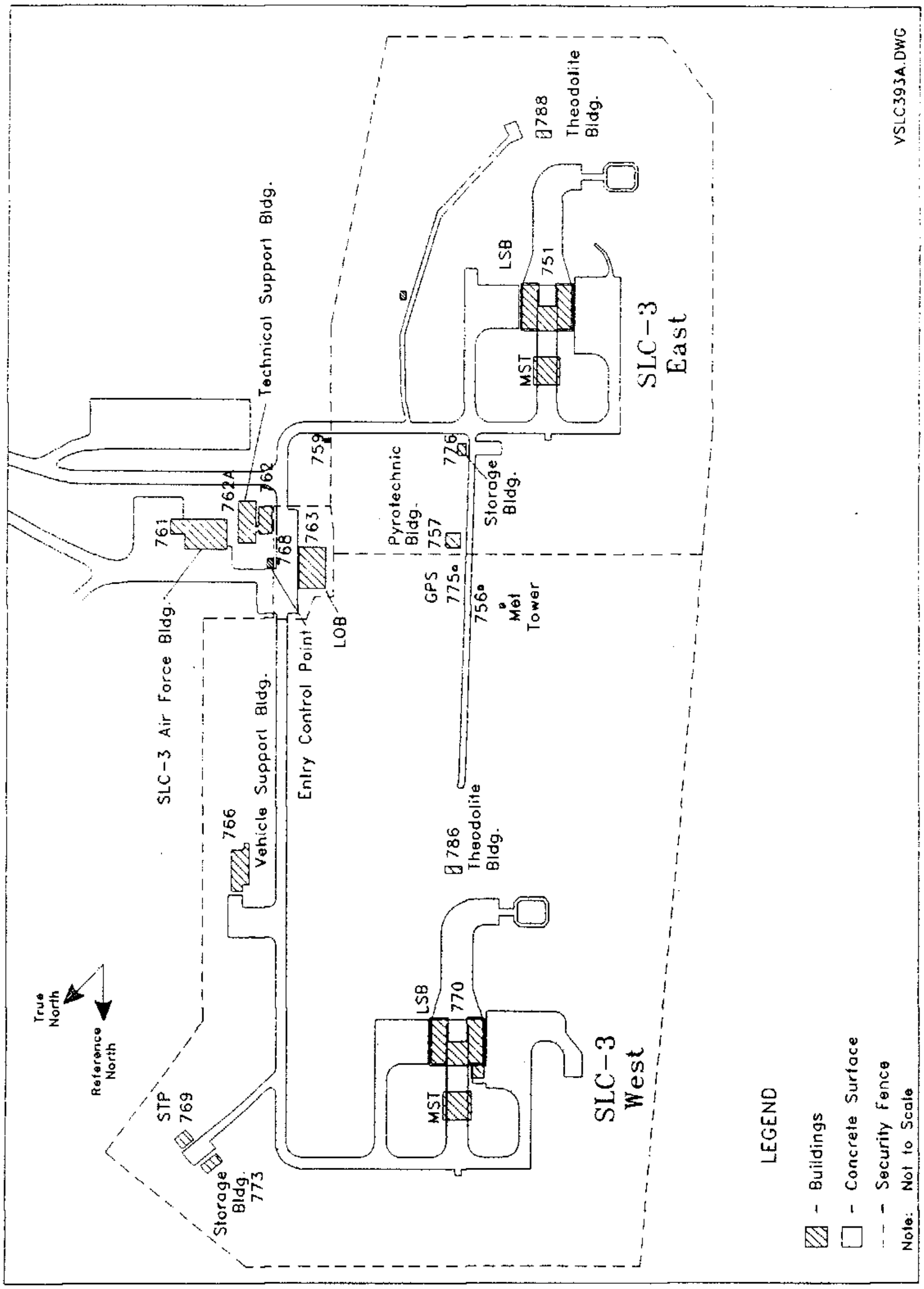


Fig. 1.3. Current configuration of SLC-3

be replaced with a stationary umbilical tower, leaving only one functional example of this technology at SLC-3W. Other modifications include replacing the Entry Control Point (Bldg. 768) and modernizing the security fence, and detection and deterrent system surrounding the complex.

Section 106 of the National Historic Preservation Act of 1966, as amended, requires a federal agency to consider the effects of its undertakings on historically significant properties, that is, on properties that are included in, or potentially eligible for inclusion in the National Register of Historic Places (NRHP). The President's Advisory Council on Historic Preservation (ACHP) published regulations implementing the requirements of Section 106 in 36 CFR 800, "Protection of Historic Properties." The USAF published regulation AFR 126-7, "Historic Preservation," to implement Section 106 requirements. These regulations require good-faith efforts on the part of USAF officials to identify any USAF properties that may be historically significant. The regulation further requires the USAF to consult with the State Historic Preservation Officer (SHPO) to jointly define the historic significance of the identified properties. During the late 1980s, Congress expressed concern regarding balancing the need to preserve the United States' technological heritage with the need to operate and upgrade scientific and technological facilities. On September 20, 1989, Congress requested that ACHP analyze the problems associated with applying the Section 106 process to continually evolving scientific and technical research facilities. In February 1991, ACHP published a report entitled "Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities" that provides guidance on reasonable application of the Section 106 process and related regulations to scientific and technological facilities.

Through a report entitled "A Historical Assessment and Effects Determination of Space Launch Complex 3, Vandenberg Air Force Base, California" (August 18, 1992), the USAF concluded that SLC-3 is historically significant; that SLC-3 is eligible for inclusion in the National Register of Historic Places; and that the proposed renovation will adversely affect SLC-3. The USAF recommended mitigating the loss of historic properties at SLC-3 by preparing narrative and photographic documentation of the complex in accordance with the specifications of the Historic American Engineering Record (HAER). On October 14, 1992, the USAF opened formal consultation with the California SHPO. In a response dated December 15, 1992, the SHPO concurred with the USAF's evaluation of SLC-3's historic significance and mitigation plan. This report is one result of that mitigation plan.

CHAPTER 2

EARLY DEVELOPMENT OF THE UNITED STATES MILITARY SPACE PROGRAM

Space Launch Complex 3 (SLC-3) at Vandenberg Air Force Base (VAFB) in California was one of the first operational installations in the United States military space program. The military space program evolved from the Cold War nuclear arms race between the United States and the Soviet Union, beginning in the mid-1950s as a defensive response to the widespread perception of a growing Soviet nuclear threat. Many of the satellites used to monitor Soviet weapons development and used as "early warning systems" for detecting Soviet missile attacks were launched from SLC-3; however, the roots of SLC-3's design and technology lay in the race to develop long-range ballistic missiles to deliver thermonuclear weapons.

Development of Ballistic Missiles in the United States

The basic concepts of the U.S. military space program evolved from American experimentation with the German V-2 rocket. The V-2 was a liquid-fueled ballistic missile developed and mass produced by the German army between 1942 and 1945. Although it had virtually no effect on the outcome of World War II, the V-2 profoundly influenced the military communities of the United States and the Soviet Union because there was no existing defense against it. No V-2s were intercepted after launch, and few were even detected before impact.[1] The team of German rocket science theoreticians who designed the V-2, led by Wernher von Braun, surrendered to American forces in May of 1945. Before the end of the war, the United States seized all of Germany's V-2 research documents and a substantial supply of rocket parts. The United States, thus, had accumulated all the principal components of the world's first successful ballistic missile program and began to experiment with it at the White Sands Missile Range in New Mexico in July of 1945. The Soviet Union had captured a V-2 production facility along with its production engineers, enabling it also to begin missile experimentation.[2] The ominous possibilities for use of the new ballistic missile technology were made dramatically apparent with the explosion of an atomic bomb over Hiroshima on August 5, 1945, and so the race began.

Although the United States appeared to have an early advantage in rocket science, the intellectual and material resources acquired at the end of the World War II were not fully exploited until Soviet missile accomplishments inspired military and public concern for national safety. After World War II, the American people were unwilling to spend substantial resources on defense, and Presidents Harry S. Truman and Dwight D. Eisenhower were intent on balancing the national budget. As a result, funding allocated to developing ballistic missile weapons systems was limited and transient. In this climate of public opposition to spending and conscientious budgeting, even less funding was available for such highly speculative experimentation as space applications of rocket science. Not until the Soviet Union's October 1957 launch of *Sputnik*, the first artificial satellite to achieve Earth-orbit, did the U.S. military receive the funding required to fully and rapidly pursue space and missile research and development. *Sputnik* changed the tide of American public opinion regarding space research and supported growing U.S. suspicion--fueled as much by Soviet propaganda as by intelligence information--that the Soviet Union had surpassed the United States in its ballistic weapons capabilities.

Despite public and political resistance, the USAF awarded a study contract to the Consolidated Vultee Aircraft Corporation (Convair)[3] on April 2, 1946, to develop a missile capable of carrying a warhead 6,000 statute miles. Under the direction of Karel J. Bossart,[4] Convair designed the MX-774, the precursor of the Atlas intercontinental ballistic missile (ICBM) and the space delivery vehicles to be launched from SLC-3. The project culminated in three test flights of MX-774 research rockets at White Sands Proving Ground, New Mexico, in 1948.[5] The MX-774 test flights established the feasibility of several design innovations that improved upon the V-2 and ultimately became universal features of rocketry (table 2.1).

Table 2.1
Comparison of V-2 and Innovative Features of MX-774[6]

V-2	MX-774
Separate, internal fuel and oxidizer tanks surrounded by an external skin	A single, stainless steel, monocoque[7] airframe in which a common bulkhead separated fuel and oxidizer compartments achieved significant weight reduction over V-2
Rudder-like graphite vanes in the rocket's exhaust stream	Gimballed engines for controlling the direction of flight improved the accuracy and range of payload delivery
Unit missile--entire missile traveled from launch to target	A separable nose cone enabled longer range for payload by removing drag of empty propellant tanks

Even with these significant advances in missile design, U.S. interest in developing ICBMs began to wane before the MX-774 test flights. An Army memorandum published in June of 1947 concluded that the only suitable use for large rockets was for the delivery of atomic weapons; however, the atomic bomb of 1947 was massive, requiring a rocket eight to ten times larger than the V-2.[8] With exclusive possession of the bomb and existing aircraft to deliver it, the U.S. Army saw no reason for the U.S. government to pursue an expensive missile development program. The Soviet Union, however, decided to develop massive rockets that would not only deliver atomic bombs but would eventually put the first man into Earth orbit.[9] The USAF terminated the MX-774 program in 1947; however, Convair continued limited ICBM research with its own funds until USAF funding was reinstated in January of 1951. The project, now entitled Atlas, produced a complete ICBM design by early 1953.[10]

By the early 1950s, onset of the Korean war; accumulation of credible intelligence suggesting that the Soviet Union was developing ballistic missiles and thermonuclear weapons faster than the United States; and confirmation of the feasibility of producing smaller, lighter nuclear warheads combined to accelerate the pace of U.S. ballistic missile development projects. A crash program to produce and deploy the Atlas ICBM began in 1954. The USAF created a new office under the Air Research and Development Command, the Western Development Division (WDD)[11] in Inglewood, California, to supervise the program. The WDD was headed by Major General Bernard A. Schriever. To further emphasize the importance of rapid development, the USAF departed from organizational tradition to install an independent contractor, Ramo-Wooldridge, in the line organization to provide technical direction for the entire Atlas program.[12] The Department of Defense made Atlas development a top priority in May 1954, and President Eisenhower accorded ICBM development highest national priority on September 8, 1955.[13]

While the Atlas ICBM was being developed, the USAF also pursued development of an intermediate range ballistic missile (IRBM) to be launched from installations in England. In December of 1955, the Air Research and Development Command awarded Douglas Aircraft Company (later to become McDonnell Douglas) a contract to develop an IRBM with a 1,500-mile range, the Thor. The goal of the Thor project was to quickly produce an operational, intermediate range missile. Thor IRBMs would close the anticipated "missile gap" between the United States and the Soviet Union until operational Atlas ICBMs could be produced and deployed in significant quantities. To achieve operational capability rapidly, Douglas agreed to incorporate as many Atlas systems and components as possible in the Thor design; consequently, the Thor was powered by an engine similar to the Atlas and fitted with an Atlas nose cone.[14]

The first Atlas ICBM test was launched on June 11, 1957, from Patrick AFB, Florida, (Cape Canaveral). By early 1958, the capability of the Atlas had been fully confirmed by several short test flights and one full-range flight (more than 6,000 miles), all launched from Patrick, AFB. Convair developed three operational versions of the Atlas ICBM:

- Atlas D, stored vertically above ground;
- Atlas E, stored horizontally in a "coffin" just below ground; the missile was erected to vertical and fueled immediately prior to launching; and

- Atlas F, stored vertically in and launched from an underground silo (missile not significantly different from Atlas E).

Atlas ICBMs were deployed at Emergency War Order (EWO) installations at or near several Air Force bases in the northern and western United States: Vandenberg, California (North VAFB); Fairchild, Washington; Warren, Wyoming; Walker, New Mexico; Offutt and Lincoln, Nebraska; Forbes and Schilling, Kansas; Altus, Oklahoma; Dyess, Texas; and Plattsburgh, New York.

The first Thor IRBM was launched from the Air Force Missile Training Center at Cape Canaveral, Florida, on January 25, 1957, only thirteen months after the beginning of the development project. The missile rose just six inches off the pad before the liquid oxygen tank ruptured, destroying the missile and seriously damaging the launch pad. By the summer of 1958, however, the Thor had passed its capability tests, and it was released to the British Royal Air Force for training and deployment in June of 1959.[15]

Space Applications of U.S. Ballistic Missile Technology

Developing rockets for space exploration had been the German rocket scientists' primary interest since the early 1900s.[16] During World War II, the German military's interest in ballistic missile weapons systems had afforded several rocket scientists an opportunity to experiment with rocket design but had frustrated their ultimate aspirations. The German V-2 scientists who assisted in U.S. experimentation at White Sands hoped again to pursue the development of rockets for manned space exploration; however, their aspirations were frustrated once more by the fluctuating U.S. interest in rocketry and its ultimate focus on weapons applications. Despite these frustrations, some space research occurred. Convair began space studies with the Atlas in 1952 but received little support for the research until after the Soviet Union's October 1957 launch of *Sputnik*. Convair's first report on the satellite capabilities of Atlas was published as a classified document in May of 1953. Under the direction of Krafft A. Ehricke, one of the German V-2 scientists who surrendered to the United States after World War II, Convair presented a comprehensive satellite and space development program based on the Atlas to U.S. government agencies in 1957.[17]

The feasibility and utility of the Atlas for space launches was demonstrated publicly on December 18, 1958, when President Eisenhower's Christmas message was broadcast via the United States' first Earth-orbiting satellite. The satellite, known as *SCORE*, was launched from Cape Canaveral aboard an Atlas B (an earlier stage in the evolution of the Atlas D ICBM).[18] The 122-pound payload consisted largely of communications relay equipment designed to tape-record radioed voice or code messages and rebroadcast them upon command from the ground. *SCORE* also assuaged the intense public concern inspired by *Sputnik* by establishing that the United States also had space capability.

Even before *SCORE* publicly established U.S. space capability, work had begun to employ the Thor as a space booster. Early in 1958, prior to completion of the first operational Atlas ICBM, the Air Force needed a reliable rocket to test a newly developed ablative nose cone being designed for the Atlas weapon system. The Thor was adapted to achieve ICBM re-entry distance and speed with the addition of a second propulsion stage, the Able, designed by Aerojet General Corporation. The success of the Thor/Able system at achieving ICBM speed and range suggested the possibility of an earlier U.S. entry into the "space race" initiated by the *Sputnik* launches. Under the management of the Defense Department's Advanced Research Projects Agency, the USAF undertook a space probe program based on the Thor. On August 17, 1958, the Thor Able 1, a four-stage system, made an unsuccessful attempt at lunar orbit. On October 11, 1958, two months prior to the *SCORE* launch, a Thor/Able 1 system successfully launched a payload 78,000 nautical miles into space, but it did not achieve orbit. Thor, however, was destined to make significant contributions to the United States military space program. On February 28, 1959, a Thor booster coupled with another second-stage, Lockheed Missiles and Space Corporation's Agena, launched the world's first polar-orbiting satellite, the *Discoverer I*, from Complex 75-3 (SLC-1) at Vandenberg Air Force Base.

Development of Reconnaissance Satellites

The U.S. military space program was defined and gained real momentum in the spring of 1960, after the Soviet Union shot down Gary Powers' U-2 reconnaissance plane. Since 1956, the U-2 had been the United States' most reliable and productive source of information about Soviet weapons development. The U-2's success, along with technical and political obstacles, had stymied military interest in developing reconnaissance satellites. Once the U-2 was proven vulnerable, however, the pace of satellite development and deployment was accelerated.[19] Powers' last mission had been to photograph a suspected Soviet ICBM site at Plesetsk. Without further intelligence, suspicions about the site could be neither confirmed, nor denied; meanwhile, the Soviet Union had become vigilant about detecting and prosecuting spies. The United States needed an alternative source of reliable photographic reconnaissance of Soviet military installations. With the development of rockets with Earth-orbiting capabilities, reconnaissance satellites gradually filled the void.

The U.S. reconnaissance satellite program actually began in the years immediately following World War II. A few farsighted individuals had seen in the V-2 the potential for reconnaissance from space. The earliest, official U.S. study of reconnaissance satellites was made by the RAND Corporation. On May 2, 1946, RAND published a 324-page report on Earth satellites that outlined scientific uses, such as studies of cosmic rays and the Earth's magnetic field, as well as military functions including reconnaissance, weather observations, and communications. There were, however, many problems to be overcome in satellite development.

The most significant technical problem in satellite development was electronics. In 1946, any satellite system would have had to rely on vacuum tubes, which were large and required considerable electrical power. The sheer weight of the tubes and the batteries to power them would have required a huge rocket. This problem began to be overcome in 1948, when Bell Telephone Laboratories invented the transistor. Transistor technology considerably reduced the weight of satellite systems. In the years that followed, electronic components were miniaturized even further so that by 1960, the equivalent of hundreds of transistors could fit onto a microchip less than an inch across. Development of the solar cell, another product of solid-state electronics, reduced the need for heavy batteries to power the satellites.

Political attitudes were even more critical than technical obstacles in delaying satellite development. Defense funding was limited in the early postwar years, and, initially, little or no money was available for developing Earth satellites. An angry public response to a brief mention of U.S. interest in satellites during a 1948 report by the Secretary of Defense highlighted the taxpayers' opposition to funding satellite development;[20] nevertheless, work continued at a low level. In April 1951, RAND Corporation research scientists wrote a secret report entitled "Utility of a Satellite Vehicle for Reconnaissance." This was followed in 1952 and 1953 by a series of reports entitled "Project Feedback;" however, neither President Eisenhower nor Defense Secretary Charles E. Wilson were interested in the military uses of satellites.[21]

By early 1955, the USAF was intent on pursuing satellite development seriously, despite lukewarm political support. In March, the USAF issued a formal request for contractor studies of strategic satellite systems under the designation WS-117L. In June of 1956, Lockheed proposed a satellite system that would be launched aboard an Atlas with an Agena second stage carrying a payload of several hundred pounds of camera equipment. Eastman Kodak and CBS Laboratories would develop a camera system in which photographs were developed aboard the satellite and radioed to ground tracking stations. The project was code-named *Pied Piper*. At the same time, RAND Corporation proposed an alternative system for returning satellite photographs. The unprocessed film would be placed in a heat-shielded capsule that could separate from the satellite, then retrofire and parachute to a landing. In mid-1957, after considerable effort, General Bernard Schriever, head of the Air Force Western Development Division, managed to obtain $10 million for space activities. The funds, however, were to be used only for developing components, not for a complete system. This limited funding meant that *Pied Piper* could not be launched before 1960.

As in the ICBM development program, the Soviet Union's launch of *Sputnik* in October 1957 spurred increased U.S. satellite development activity. The funding for *Pied Piper* was quadrupled in late November of 1957, and in January of 1958, President Eisenhower approved a major new program to develop and test the capsule-recovery system proposed by RAND. The technological advances required to complete the radio-transmission reconnaissance satellite, *Pied Piper*, would prevent it from meeting the immediate need for a reconnaissance satellite, and the Atlas was just beginning to be tested. The capsule-recovery satellite system required fewer technological innovations for the camera and would be launched from the already operational Thor IRBM with an Agena second stage. The budget for the project was $150 million.[22] The capsule-recovery satellite system was named *Discoverer*, and testing began in January of 1959. At the same time that the launch and capsule-recovery sequence[23] was being tested with *Discoverer 11*, Gary Powers was shot down over the Soviet Union, necessitating immediate deployment of an operational reconnaissance satellite system.

By the time of President John F. Kennedy's inauguration in January of 1961, the radio-transmission reconnaissance satellite, now renamed *Samos*, was being tested, and the *Discoverer* program was returning some satellite photographs, although none had satisfactorily answered questions about Soviet ICBM capabilities. President Kennedy immediately ordered a moratorium on all public information regarding military space activities, and the payloads of most launches were classified for several years thereafter. Until this time, there had been extensive press coverage of satellite test launches. The early *Discoverer* tests had been problematic, and faced with Soviet Premier Nikita Khrushchev's bold military posturing and increasing pressure regarding Western presence in Berlin, President Kennedy could not afford to publicize less-than-successful military space operations. The Soviet Union had established its position of unchallenged strength and prestige with the manned orbit of the *Vostok 1* on April 5, 1961. Five days later, President Kennedy's inaction during the Bay of Pigs incident was perceived in the Soviet Union as a sign of U.S. vacillation and weakness, leaving Premier Khrushchev free to make an ultimatum: Western presence should be removed from Berlin by December 31, 1961.[24] That summer, however, a series of successful *Discoverer* satellites returned photographs that destroyed the Soviet posture of superior nuclear weapons strength and settled the Berlin dispute. The *Discoverer* satellites had surveyed the whole of the Soviet land mass and showed only one ICBM launch site at Plesetsk and only four missiles.[25] The missile gap was closed, and the United States could safely take a much more forceful stance on the Berlin issue. This success firmly established the U.S. military space program as an important defensive strategy in the Cold War.

Development of a Military Space Installation at Vandenberg Air Force Base

As development of reconnaissance satellites got fully underway in 1958, work also began to select an appropriate operational launch site. Reconnaissance satellites require polar orbits to achieve complete coverage of all inhabited land masses. Cape Canaveral, the USAF's designated research and development test launch center, was not an appropriate site for launching reconnaissance satellites because only equatorial orbits could be achieved safely from the Cape. Polar orbits could be achieved without passing over any populated land masses from a former military site near Lompoc, California (fig. 1.1). The advantages of the site, a deactivated World War II Army base called Camp Cooke, included its large size, remote location away from heavily populated areas, access to the Pacific Ocean as a test range, good weather, and existing infrastructure.

Camp Cooke had been selected as the USAF's ballistic missile weapons testing and training site in 1956. The 65,000-acre portion of the camp north of the Santa Ynez River (fig. 1.2) was transferred to the Air Research and Development Command and named Cooke Air Force Base in 1957. The Strategic Air Command assumed responsibility for the base in 1958, and it was renamed Vandenberg Air Force Base (VAFB). The Air Force committed over $178 million for improvements at VAFB, including more than $120 million for ICBM and IRBM launch complexes. By the end of 1959, six missile launch complexes had been constructed on what is now called North VAFB. Early testing for the *Discoverer* satellite program was conducted from a Thor IRBM launch complex at North VAFB, and *Discoverer 1*, the world's first polar-orbiting satellite, was launched from Complex 75-3-4 (SLC-1W) at North VAFB on February 28, 1958. In late 1959, the Air Force proposed converting three Atlas ICBM pads on North VAFB into research and development facilities for launching military satellites into polar orbit across Point Arguello. This proposal initiated a conflict over space program responsibilities with the other tenant of the former Camp Cooke, the U.S. Navy.

The Defense Department transferred the 20,000-acres of Camp Cooke south of the Santa Ynez River (fig. 1.2) to the Navy in December of 1957. Under the auspices of the Naval Missile Test Center at Point Mugu, the Pacific Missile Range (PMR), which included the Naval Missile Test Facility at Point Arguello, was commissioned in June of 1958 to expand the Navy's West Coast missile range facilities. The Navy spent more than $200 million to develop Point Arguello into a premier space and missile installation. Through the PMR, the Navy provided equipment and ground support to the USAF and the Army for testing missile weapons systems and access to polar orbits for a wide variety of defense and scientific space studies.

Although the Defense Department had given the USAF the primary space mission, including control of all military space boosters, the Navy had been given the mission of operating PMR. Recognizing that the military space operations beginning at North VAFB and the operation of the PMR were clearly related, the USAF and the Navy entered an agreement for coordinated use of the PMR. The agreement signed by Air Force Chief of Staff Thomas D. White and Navy Chief of Operations Arleigh Burke on March 5, 1958, gave the Navy responsibility for establishing a joint agency for coordinating radio frequencies; providing frequency surveillance; coordinating and scheduling launches and firings from PMR; ensuring range safety, including actuation of inflight destruction devices for missiles launched into the PMR (except those launched from North VAFB); preventing duplication of facilities and equipment in or for operation on the PMR; and providing all basic instrumentation, communications facilities, support, and services required by range users.[26]

Despite the White-Burke agreement, a pungent argument over the relative missions of North VAFB and the PMR facilities at Point Arguello continued. The USAF contended that the Navy was attempting to usurp control of USAF efforts to develop operational military space systems; whereas, the Navy considered USAF research and development activities at North VAFB to overlap the function of the PMR, which the Navy hoped to develop into a western Cape Canaveral.[27] Nevertheless, the Navy constructed two Atlas launch pads at Point Arguello Launch Complex 1 (PALC-1; which later became SLC-3) for the USAF's *Samos* reconnaissance satellite program. The conflict between the two branches of the military intensified during construction of the Atlas pads because the trajectory of early *Discoverer* test flights crossed Point Arguello. The Navy, being in charge of range safety, insisted on evacuating the construction site and halting all traffic on an adjacent, main line of the Union Pacific Rail Road during *Discoverer* launches, causing costly delays in the construction of PALC-1(SLC-3).

This conflict was resolved on November 16, 1963, when the Secretary of Defense issued a memorandum entitled "Management and Organization of DOD Ranges and Flight Test Facilities," providing instructions for the dissolution of PMR.[28] As a result of this memo, Point Arguello was transferred to the USAF on July 1, 1964. Point Arguello was renamed South VAFB, and the PMR was renamed the Western Test Range. Regular space launches from PALC-1 using Atlas and Thor delivery vehicles with a variety of upper-stage space vehicles and satellite payloads had begun in 1960.

1. Michael C. Quinn, White Sands Missile Range V-2 Rocket Facilities, (HAER No. NM-1B), July 1986.

2. Ibid.

3. In 1953, Convair became a division of General Dynamics.

4. Bossart was awarded the Exceptional Civilian Service Award by Air Force Secretary James H. Douglas in 1958. For additional information about Bossart and the early development of the Atlas, see Richard E. Martin, The Atlas and Centaur "Steel Balloon" Tanks: A Legacy of Karel Bossart, 40th International Astronautical Congress Papers 1 AA-89-738, October 1989.

5. General Dynamics, Atlas History (unpublished).

6. General Dynamics, Atlas Fact Sheet September 15, 1959.

7. A balloon with no internal structure.

8. Wernher von Braun and Frederick I. Ordway III, History of Rocketry and Space Travel (third rev. ed.: New York: Thomas Y. Crowell Co., 1975). The memo was entitled "Operational Requirements for Guided Missiles."

9. Quinn, White Sands Missile Range.

10. General Dynamics, Atlas Fact Sheet.

11. The Air and Research Development Command - Western Development Division later became the Strategic Air Command - Ballistic Missile Division.

12. von Braun and Ordway, History of Rocketry and Space Travel. Ramo-Wooldridge later combined with the Thompson Company to form TRW, Inc., the current USAF space integration contractor.

13. Julian Hartt, The Mighty Thor: Missile in Readiness (New York: Duell, Sloan, and Pearce, 1961).

14. Ibid.

15. Ibid.

16. Willy Ley, Rockets, Missiles, and Men in Space (New York: The Viking Press, 1968).

17. General Dynamics, Atlas Fact Sheet.

18. Ley, Rockets, Missiles, and Men.

19. Curtis Peebles, GUARDIANS Strategic Reconnaissance Satellites (Novato, CA: Presido Press, 1987).

20. Ibid.

21. Ibid.

22. Ibid.

23. Capsules were recovered in mid-air by a C-119 air plane with a snag apparatus to pluck the capsule's parachute out of the air; later by JC-130A aircraft.

24. Peebles, Guardians.

25. Ibid.

26. James Baar and William E. Howard, "AF-Navy Space Range Flight Nears Showdown," Missiles and Rockets (21 December 1959).

27. James Baar and William E. Howard, "Navy Pushes for 'Perfect' Space Range," Missiles and Rockets (28 December 1959).

28. Anonymous, Days of Challenge Years of Change: A Technical History of the Pacific Missile Test Center, (Washington, D.C.: Government Printing Office).

CHAPTER 3

CONSTRUCTION, LAUNCH, AND COMMAND HISTORY OF SPACE LAUNCH COMPLEX 3 AT VANDENBERG AIR FORCE BASE

Construction History

Construction of Point Arguello Launch Complex 1 (PALC-1; later SLC-3) began in 1959 under the administration of the Navy Bureau of Docks and Yards. The complex was designed to launch *Samos* and *Midas* surveillance satellites using modified Atlas D ICBMs with Agena upper stages. Original design drawings for PALC-1 were prepared by the architectural-engineering firm of Ralph M. Parsons in 1957. The five million dollar construction contract for the launch complex was awarded to Wells Benz, Inc. The A-frame gantries were built by H.E. Robertson Co.[1] Construction was completed on September 10, 1959. Two virtually identical launch pads, PALC-1-1 (later SLC-3W) and PALC-1-2 (later SLC-3E), were the main features of the complex. The first launch from PALC-1-1 (SLC-3W) took place on October 11, 1960; the first launch from the PALC-1-2 (SLC-3E) took place on July 12, 1961. PALC-1 was renamed Space Launch Complex 3 (SLC-3) in July 1964.

Both launch pads at SLC-3 have undergone several major modifications to accommodate changes in delivery vehicles (also called launch vehicles or boosters) and space vehicles (a space vehicle may be a satellite payload alone or in combination with an upper stage that accompanies the satellite into orbit). Both pads at SLC-3 were originally configured for Atlas D/Agena vehicles. At the conclusion of the Atlas D/Agena program in 1963, SLC-3W was converted to accommodate Thor/Agena vehicles, and SLC-3E became inactive. Between November 1965 and June 1966, SLC-3E launched Atlas SLVs. After only two years of activity, however, SLC-3E again became inactive. In 1965, 135 surplus Atlas E and F ICBMs were assigned to the Air Force Space and Missile Systems Organization (SAMSO) for use in the military space program; consequently, SLC-3W was modified to launch Atlas E and F delivery vehicles in 1974, after the Thor/Agena program was completed. SLC-3W is still operating in Atlas E/F launch configuration, and the four remaining Atlas E vehicles assigned to SLC-3 are expected to be launched from the west pad before the end of 1994. Conversion of SLC-3E to Atlas E/F launch configuration was completed in 1976. The last modification at SLC-3E, converting the pad to Atlas H configuration, was completed in 1982. Atlas H vehicles were launched from SLC-3E until 1987, when the pad was placed in caretaker status (no launch activity, minimum maintenance). The Air Force is planning to modify SLC-3E to Atlas II launch configuration beginning in 1993.

Most modifications of the launch pads at SLC-3 have been made to accommodate differences in the characteristics of the delivery vehicles to be launched from the pads. Changes in delivery vehicles launched from SLC-3 have been based on availability of surplus ICBMs or IRBMs, the requirements of particular satellite programs, or both. Contrary to the trend toward miniaturization common in many other industries, the trend in both the military and civilian space programs has been toward heavier space vehicles, which require more powerful delivery vehicles to achieve orbit. Although the electronic components of satellites have been miniaturized, payloads have become multifunctional so that several types of equipment are often carried on one space vehicle. As military and civilian space programs evolved, the lifetimes of satellites have increased steadily, requiring larger, more durable power sources and backup batteries as standard equipment. In addition, modern military satellites typically include protective features such as external cladding and sensors for detecting antisatellite devices, which contribute additional weight to the space vehicle.[2,3] All of these factors combine to require larger delivery vehicles, which is one reason for the planned modifications of SLC-3E to accommodate the Atlas II series. Typical modifications of launch pad structures at SLC-3 for various delivery and space vehicle programs are described in detail in Chapter 5.

Launch History

The primary function of SLC-3 has been to deliver reconnaissance, meteorological, and navigational satellites into polar orbit for the military space program. Since 1960, there have been one hundred launches from SLC-3: twenty-eight from SLC-3E, and seventy-two from SLC-3W. Tables 3.1 and 3.2 list all launches from SLC-3E and SLC-3W, respectively.

SLC-3's launch history has been marked by several noteworthy events, including program "firsts", accidents, and record launches. The first *Samos* was launched from SLC-3W on October 11, 1960. SLC-3E was the site of the first *Midas* launch from the West Coast. This launch occurred on July 12, 1961, when an Atlas D/Agena B lifted *Midas 3* into orbit. Although they are rare, several dramatic accidents have occurred at SLC-3. On September 9, 1961, the Atlas/Agena B vehicle carrying *Samos-3* exploded on the SLC-3W launch pad. On two occasions, personnel were confined inside the Launch Operations Building (Bldg. 763) for several hours to protect them from potentially hazardous conditions on the launch pad. This happened first when a Thor/Agena D vehicle launched from SLC-3W on February 17, 1971, exploded twenty-three seconds after lift off. A similar accident occurred on December 18, 1981, when an Atlas E carrying a *NAVSTAR GPS* payload launched from SLC-3E had to be destroyed about 1,000 feet above the pad, landing just outside the SLC-3 perimeter fence. Although crews from the surrounding buildings and from VAFB Safety Operations were outside during both these accidents, SLC-3 safety procedures required the launch control crew to remain inside the Launch Operations Building for more than five hours each time. On November 28, 1991, SLC-3W was the site of the five-hundredth launch of an Atlas (includes all experimental models, ICBMs, and space delivery vehicles). The five-hundredth Atlas launch had been anticipated to occur at Cape Canaveral, but technical difficulty delayed that mission, leaving the SLC-3 launch next in line. This successful launch of a *DMSP* satellite also marked the one-hundredth launch from SLC-3.

Table 3.1
Launches From Space Launch Complex 3-East

Launch Date (m/d/y)	Vehicle	Payload	Comments
07/12/61	Atlas 97D/Agena B-Type 1	*Midas 3*	First *Midas* launch from West Coast
10/21/61	Atlas 105D/Agena B-Type 1	*Midas 4*	Achieved orbit
12/22/61	Atlas 114D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 8/14/62
03/07/62	Atlas 112D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 6/7/63
04/09/62	Atlas 110D/Agena B-Type 1	Classified	Achieved orbit
12/17/62	Atlas 131D/Agena B-Type 1	Classified + *ERS 3,4*	Failed to achieve orbit
05/09/63	Atlas 119D/Agena B-Type 1	Classified + *ERS 5,6*	Achieved orbit
06/12/63	Atlas 139D/Agena B-Type 1	Classified + *ERS 7,8*	Failed to achieve orbit
07/18/63	Atlas 75D/Agena B-Type 1	Classified + *ERS 9,10*	Achieved orbit
06/09/66	Atlas 7201SLV/Agena D-4	Classified + *SECOR-6* + *ERS 16*	Achieved orbit
8/19/66	Atlas 7202SLV/Agena D-4	Classified + *EGRS 7* + *ERS 15*	Achieved orbit
10/05/66	Atlas 7203SLV/Agena D-4	Classified + *EGRS 8*	Achieved orbit
12/21/66	Atlas 7011SLV	*PRIME*	Space vehicle re-entry testing; achieved mission
03/05/67	Atlas 7002SLV	*PRIME*	Space vehicle re-entry testing; achieved mission

Table 3.1 (Continued)

Launch Date (m/d/y)	Vehicle	Payload	Comments
04/19/67	Atlas 7003SLV	*PRIME*	Space vehicle re-entry testing; achieved mission
08/16/68	Atlas 7004SLV/Burner II	Many subsatellites	Payload included at least 10 small subsatellites
02/22/78	Atlas 64F	*NAVSTAR GPS NDS 1*	Achieved orbit
05/13/78	Atlas 49F	*NAVSTAR GPS NDS 2*	Achieved orbit
10/16/78	Atlas 47F	*NAVSTAR GPS NDS 3*	Achieved orbit
12/10/78	Atlas 39F	*NAVSTAR GPS NDS 4*	Achieved orbit
02/09/80	Atlas 35F	*NAVSTAR GPS NDS 5*	Achieved orbit
04/26/80	Atlas 34F	*NAVSTAR GPS NDS 6*	Achieved orbit
12/18/81	Atlas 76E	*NAVSTAR GPS NDS 7*	Launch failed
02/09/83	Atlas 6001H/ABSAD	Classified	Achieved orbit
06/09/83	Atlas 6002H/ABSAD	Classified	Achieved orbit
02/05/84	Atlas 6003H/ABSAD	Classified	Achieved orbit
02/09/86	Atlas 6004H/ABSAD	Classified	Achieved orbit
05/15/87	Atlas 6005H/ABSAD	Classified	Achieved orbit

Sources: Vandenberg AFB Launch Summary (1992); TRW Space Log (1988 through 1991); Interavia Space Directory (1990-1991).

Acronyms:

ABSAD	Atlas Booster Satellite Dispenser
ERS	Environmental Research Subsatellite
GPS	Global Positioning System
NAVSTAR	Navigational System Using Timing and Ranging
NDS	Navigation Development Satellite
PRIME	Precision Recovery Including Maneuverable Entry

Table 3.2
Launches From Space Launch Complex 3-West

Launcb Date (m/d/y)	Vehicle	Payload	Comments
10/11/60	Atlas 57D/Agena A	*Samos 1*	Failed to achieve orbit
01/31/61	Atlas 70D/Agena A	*Samos 2*	Achieved orbit; orbit decayed 10/21/73
09/09/61	Atlas 106D/Agena B-Type 2	*Samos 3*	Exploded on launcb pad
11/22/61	Atlas 108D/Agena B-Type 2	Classified	Failed to achieve orbit
04/26/62	Atlas 118D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 04/28/62
06/17/62	Atlas 115D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 06/18/62
07/18/62	Atlas 120D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 07/25/62
08/05/62	Atlas 124D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 08/06/62
11/11/62	Atlas 128D/Agena B-Type 2	Classified	Achieved orbit; orbit decayed 11/12/62
11/27/63	Thor/Agena D	Classified	Achieved orbit; orbit decayed 12/15/63
03/24/64	TAT/Agena D	Classified	Failed to achieve orbit
06/04/64	TAT/Agena D	Classified	Achieved orbit; orbit decayed 06/18/64
07/10/64	TAT/Agena D	Classified	Achieved orbit; orbit decayed 08/06/64
09/14/64	TAT/Agena D	Classified	Achieved orbit; orbit decayed 10/06/64
11/17/64	TAT/Agena D	Classified	Achieved orbit; orbit decayed 11/04/64
02/25/65	TAT/Agena D	Classified	Achieved orbit; orbit decayed 03/18/65
03/29/65	TAT/Agena D	Classified	Achieved orbit; orbit decayed 05/26/65
07/19/65	TAT/Agena D	Classified	Achieved orbit; orbit decayed 08/18/65
08/17/65	TAT/Agena D	Classified	Achieved orbit; orbit decayed 10/11/65
09/22/65	TAT/Agena D	Classified	Achieved orbit; orbit decayed 11/17/65
02/02/66	TAT/Agena D	Classified	Achieved orbit; orbit decayed 02/27/66
04/07/66	TAT/Agena D	Classified	Achieved orbit; orbit decayed 04/26/66
05/22/66	TAT/Agena D	Classified	Achieved orbit; orbit decayed 06/09/66
09/20/66	TAT/Agena D	Classified	Achieved orbit; orbit decayed 10/12/66

Table 3.2 (Continued)

Launch Date (m/d/y)	Vehicle	Payload	Comments
01/14/67	TAT/Agena D	Classified	Achieved orbit; orbit decayed 02/02/67
02/22/67	TAT/Agena D	Classified	Achieved orbit; orbit decayed 03/11/67
03/30/67	TAT/Agena D	Classified	Achieved orbit; orbit decayed 04/17/67
05/01/68	TAT/Agena D	Classified	Achieved orbit; orbit decayed 05/15/68
08/07/68	TAT/Agena D	Classified	Achieved orbit; orbit decayed 08/27/68
11/03/68	TAT/Agena D	Classified	Achieved orbit; orbit decayed 11/23/68
12/12/68	LTTAT/Agena D	Classified	Two satellites achieved orbit; one orbit decayed 12/28/68. The other satellite remains in its original orbit
02/05/69	LTTAT/Agena D	Classified	Two satellites achieved orbit; one orbit decayed 02/24/69. The other satellite remains in its original orbit.
03/19/69	LTTAT/Agena D	Classified	Two satellites achieved orbit; orbits decayed 03/24/68 and 12/06/71
05/01/69	Thorad/Agena D	Classified	Two satellites achieved orbit; orbits decayed 05/23/69 and 02/16/70
07/23/69	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 08/23/69
09/22/69	Thorad/Agena D	Classified	Two satellites achieved orbit; orbits decayed 10/12/69 and 05/16/71
12/04/69	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 01/10/70
04/30/70	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 03/26/70
05/20/70	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 06/17/70
07/22/70	Thorad/Agena D	Classified	Achieved orbit
11/18/70	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 12/11/70
02/17/71	Thorad/Agena D	Classified	Launch failed
03/24/71	LTTAT/Agena D	Classified	Achieved orbit; orbit decayed 04/12/71
09/10/71	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 10/05/72
04/19/72	LTTAT/Agena D	Classified	Achieved orbit; orbit decayed 05/12/72

Table 3.2 (Continued)

Launch Date (m/d/y)	Vehicle	Payload	Comments
05/25/72	Thorad/Agena D	Classified	Achieved orbit; orbit decayed 06/04/72
07/13/74	Atlas 69F	*Timation 3*	Navigation technology; satellite remains in orbit. Also called NTS-I
04/12/75	Atlas 71F	Classified	Launch failure
06/23/77	Atlas 65F	*NTS II*	Precursor of *NAVSTAR GPS* satellites
06/26/78	Atlas 23F/Agena D	*Seasat*	Experimental ocean survey; satellite died 10/09/78
10/13/78	Atlas 29F	*TIROS N*	Meteorological; satellite remains in orbit
02/24/79	Atlas 27F	*Solwind P78-1*	Ionosphere and magnetosphere research; satellite struck by USAF ASAT 09/13/85; 163 pieces in orbit
06/27/79	Atlas 25F	*NOAA A (6)*	Letter designation prior to launch, number assigned after orbit achieved; meteorological; remains in orbit
05/29/80	Atlas 19F	*NOAA B*	Meteorological; decayed 05/03/81; attained an unusable orbit
06/23/81	Atlas 87F	*NOAA C (7)*	Meteorological; remains in orbit
12/20/82	Atlas 60E	*DMSP 6*	Meteorological
03/28/83	Atlas 73E	*NOAA E (8)*	Achieved orbit; battery exploded 12/30/85
07/14/83	Atlas 75E	*NAVSTAR GPS 8*	Navigation
11/17/83	Atlas 58E	*DMSP 7*	Meteorological
06/13/84	Atlas 42E	*NAVSTAR GPS 9*	Navigation
09/08/84	Atlas 14E	*NAVSTAR GPS 10*	Navigation
12/12/84	Atlas 19E	*NOAA F (9)*	Meteorological
03/12/85	Atlas 41E	*Geosat*	Ocean mapping; replaced *Seasat*
10/08/85	Atlas 55E	*NAVSTAR GPS 11*	Navigation

Table 3.2 (Continued)

Launch Date (m/d/y)	Vehicle	Payload	Comments
09/17/86	Atlas 52E	*NOAA G (10)*	Meteorological
06/19/87	Atlas 59E	*DMSP 8*	Meteorological
02/02/88	Atlas 54E	*DMSP 9*	Meteorological
08/24/88	Atlas 63E	*NOAA H (11)*	Navigation; includes search and rescue features
04/11/90	Atlas 28E	*USA 56, 57, 58*	Military communications
12/01/90	Atlas 61E	*DMSP 10*	Operational but not in desired orbit
05/14/91	Atlas 50E	*NOAA D (12)*	Meteorological
11/28/91	Atlas 53E	*DMSP 11*	Meteorological

Sources: Vandenberg AFB Launch Summary (1992); TRW Space Log (1988 through 1991); Interavia Space Directory (1990-1991).

Acronyms:

ASAT	Antisatellite device
DMSP	Defense Meteorological Satellite Program
GPS	Global Positioning System
LTTAT	Long Tank Thrust Augmented Thor
NAVSTAR	Navigational System Using Timing and Ranging
NTS	Navigation Technical Satellite
TAT	Thrust Augmented Thor

Command History

Although VAFB was originally a Strategic Air Command (SAC) base, space launches from South VAFB were never SAC responsibility. A succession of USAF research and development commands have been responsible for space launches from South VAFB. Figure 3.1 presents a timeline of military command at the PALC-1/SLC-3 military command timeline. The Air Research and Development Command (ARDC) was the first command at Vandenberg. Although VAFB's Launch Chronology 1958-1992 lists the Air Force Systems Command (AFSC) as having been responsible for the first launch from SLC-3 (then known as PALC-1), this launch and one additional launch actually took place under ARDC command. ARDC became AFSC on April 1, 1961. After that date, AFSC was responsible for all space launches from VAFB until October 1, 1990, when responsibility for Department of Defense space launches from Vandenberg passed from AFSC to Air Force Space Command (AFSPACECOM). VAFB was formally transferred from SAC to AFSPACECOM in January 1991.

Space launch operations under ARDC were controlled by its Ballistic Missile Division (BMD); the active launch unit was the 6565th Test Wing, established October 20, 1960. When ARDC became AFSC, BMD split into two parts--the Ballistic Systems Division (BSD for ICBM programs) and the Space Systems Division (SSD for space launch operations). Even though the Air Force conducted space launches from PALC-1, this space launch complex was located on Navy property. The Naval Missile Test Facility at Point Arguello was designated for transfer to the Air Force in November 1963. Thus, on May 15, 1964, the Air Force established the Air Force Western Test Range under SSD to control satellite launch operations from VAFB (this was a redesignation of the Air Force Space Test Center, Provisional, which operated from January 2 through May 15, 1964).

In 1967, BSD and SSD combined to form the Space and Missile Systems Organization (SAMSO). The Air Force Western Test Range continued satellite launches until April 1, 1970, when the HQ Space and Missile Test Center (SAMTEC) was established through the 6595th Space Test Group (later the 6596th Satellite Test Group, followed by the 6595th Aerospace Test Group) of the 6595th Aerospace Test Wing (activated May 1, 1970). On October 1, 1979, SAMSO split into two parts--the Ballistic Missile Office (to handle ICBM programs) and the Space Division. The Space Division now controlled the Space and Missile Test Organization (SAMTO), whose Western Space and Missile Center (WSMC) at VAFB conducted polar orbit space launches, including those from SLC-3.

SAMTO was dissolved on October 1, 1989, one year prior to AFSPACECOM's assumption of space launch responsibilities. AFSPACECOM also took command of the Western Space and Missile Center, reporting through a new unit--the 9th Space Division, at Patrick AFB, Florida. Atlas launches at Vandenberg were conducted by the 2d Space Launeh Squadron. This

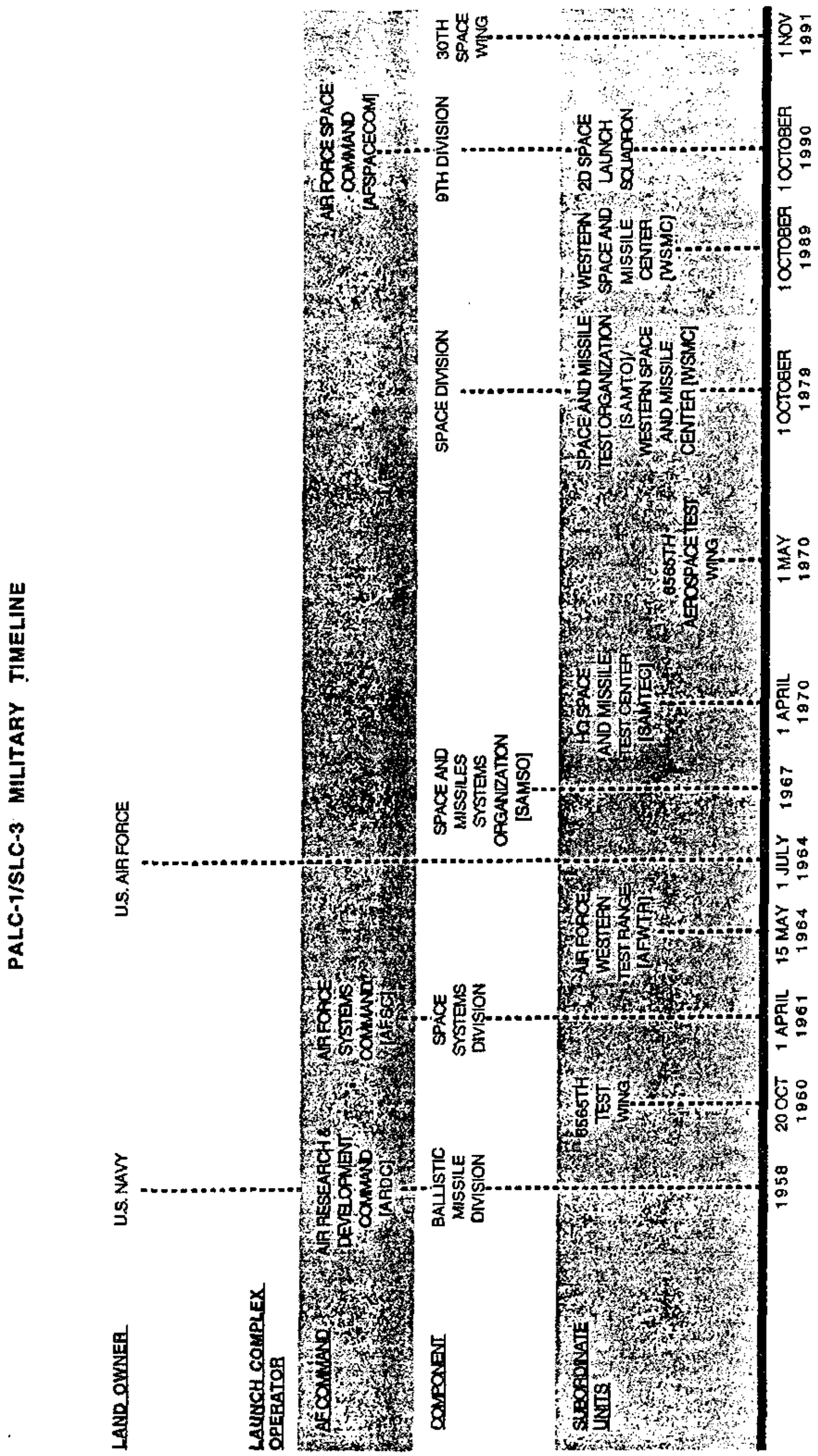


Fig. 3.1. PALC-1/SLC-3 military command timeline

changed in 1991 when the 9th Space Division was deactivated. A month later, WSMC was redesignated the 30th Space Wing, the unit currently responsible for space launches from VAFB.

Payloads Launched from SLC-3

Payloads launched from SLC-3 have included early warning and reconnaissance satellites, navigational satellites, and meteorological satellites supporting military operations. Table 3.3 summarizes the number of launches and periods of activity for each type of payload launched from SLC-3.

Table 3.3
Summary of Payloads Launched from SLC-3

Payload/Program	Period of SLC-3 Activity	Number of Launches	
		SLC-3E	SLC-3W
Samos	Oct. 1960-Sept. 1961	0	3
Midas	Jul. 1961-Oct. 1961	2	0
Classified	Nov. 1961-Apr. 1975	10	44
PRIME	Dec. 1966-Apr. 1967	3	0
NTS (*NAVSTAR* precursor)	Jul. 1974, Jun. 1977	0	2
NAVSTAR	Feb. 1978-Oct. 1985	7	4
Seasat	Jun. 1978	0	1
Geosat	Mar. 1985	0	1
TIROS N	Oct. 1978	0	1
NOAA	Jun. 1979-May 1991	0	8
DMSP	Dec. 1982-Nov. 1991	0	6
Classified	Feb. 1983-May 1987	5	0

The first satellites launched from SLC-3 were the *Samos* reconnaissance satellites and the *Midas* early warning satellites for detection of Soviet ICBM launches. The payloads of ten of the first thirteen launches from SLC-3E (1961 through 1966) are classified. The payloads of forty-three of the forty-six launches from SLC-3W between 1960 and 1972 are classified. These early launches from SLC-3 took place during the critical period of the Kennedy Administration, when Cold War tensions between the United States and the Soviet Union were peaking. After 1972, programs from both pads included meteorological payloads sponsored by the National Oceanic and Atmospheric Administration (NOAA) and the Defense Meteorological Satellite Program (DMSP), navigation aids such as *Navigational System Using Timing and Ranging (NAVSTAR) Global Positioning System (GPS)* satellites, and ocean mapping and surveillance payloads such as *Seasat*, *Geosat*. Although some payloads were sponsored by civilian organizations such as NOAA and the National Aeronautics and Space Administration (NASA) for scientific inquiry, most have had applications of interest to the military as well.

Satellite Missile Observation System (*Samos*)

Samos was one of the first reconnaissance satellites developed by the United States. Along with *Discoverer*, *Samos* evolved from the Air Force's WS-117L "Strategic Satellite System" program of 1956-1957. Five launches for the *Samos* program were planned during 1960 and 1961, all from SLC-3. The first *Samos* was launched from SLC-3W on October 11, 1960. The launch was successful, but the satellite failed to orbit. *Samos 2* was launched from SLC-3W on January 31, 1961. This satellite reached orbit, and its transmissions continued for nearly a month while the satellite made more than 500 circuits of the Earth. *Samos 2* was the most successful member of the program. Secrecy regarding U.S. military space launches increased throughout 1961, and most launches of reconnaissance satellites after *Samos 2* were classified. *Samos 3* was named, but the launch was not publicized, in part because the vehicle exploded on the launch pad. Little information about *Samos 3* or any subsequent *Samos* launches was released for the official record.

Missile Detection Alarm System (*Midas*)

Midas was developed from the same WS-117L program from which *Samos* and *Discoverer* evolved; however, *Midas'* purpose was different. *Midas* was designed to detect Soviet ICBM launches using infrared sensors to identify the hot exhaust of liquid-fueled rockets. *Midas 1* and *2* were launched from Cape Canaveral. *Midas 3*, launched on July 12, 1961, was the first satellite launched from SLC-3E. *Midas 4* was launched from SLC-3E on October 21, 1961. *Midas 3* and *4* were intended to demonstrate the high polar orbit (approximately 3,700 kilometers) required for the early warning system. They were launched aboard Atlas D/Agena B vehicles. The Agena B had longer propellant tanks than the Agena A used on *Midas 1* and *2*. *Midas 3* and *4* were to have a longer, one-year life and required twice the propellant of the first two *Midas* satellites to reach high polar orbit. The satellites themselves, however, were lighter than *Midas 1* and *2* due to a smaller infrared scanner built by Baird-Atomic and the use of solar panels instead of batteries for satellite power. Both *Midas 3* and *4* achieved their intended orbits, but neither was in place long enough to detect an ICBM launch. During the time these satellites were in orbit, missiles were launched from Vandenberg and from Cape Canaveral to test the infrared scanner, but no useful data were returned.

Ground-based, radar early-warning systems of the late 1950s and early 1960s could detect missiles no sooner than fifteen minutes after launch; however, the satellite early warning system using infrared sensors theoretically would be able to detect a launch as it occurred, providing extra mobilization time in case of a Soviet attack. The *Midas* system was designed to consist of eight satellites in two high-orbital rings, providing full coverage of Soviet territory and some redundancy for increased reliability. The satellites were to be placed in elliptical orbits by an Atlas and coast halfway around the world until reaching the high point of orbit. At that point, the Agena engine would fire to circularize the orbit. The Agena engine could be fired periodically to maintain equal spacing between the satellites. The infrared detectors were positioned in the nose cone of the Agena and would be oriented to face Earth when in the high-polar, circular orbit. *Midas* was expected to provide 80 to 100 percent chance of detection, depending on the location of a Soviet launch (100 percent for Plesetsk, 86 percent for Tyuratam).[4] Upon detection of an ICBM launch, the satellite would transmit a radio warning to Earth. The system was also capable of monitoring the location and direction of missiles in flight.

The little data returned from early *Midas* missions identified serious technical problems. Several false alarms were produced because rocket exhaust "looked" similar to many natural features, including sunlight reflected from clouds.[5] Political pressure to achieve operational success before baseline infrared data on rocket exhaust for comparison with potential competing heat sources could be collected further hindered the effort to perfect the satellite early warning system.[6] These problems were overcome by the mid-1960s, but the concept did not prove to be as simple as initially anticipated.

Because of President John F. Kennedy's security policy, early warning-system missions subsequent to *Midas 3* and *4* were classified. SLC-3E became the launch base for the early warning satellite program, including several follow-ons to the *Midas* system. Nine of the ten classified launches from SLC-3E during the period from 1961 through 1966 were associated with infrared early warning system satellite programs.[7] The first undesignated *Midas* follow-on launches from SLC-3E took place on April 9, 1962, and December 17, 1962. The second undesignated *Midas* follow-on satellite failed to orbit because of an Agena B problem. Success was finally achieved with the mission launched on May 9, 1963. This satellite operated for six weeks and detected Titan and Atlas ICBM test-launches, as well as test-launches of two solid-propellant rockets, Minuteman and Polaris. This was a significant achievement for an infrared detection system that had been designed to detect only hotter, longer-burning, liquid-fueled missiles. A launch on June 12, 1963, failed to orbit. The July 18, 1963, launch was considered another major success. Although short-lived, the satellite detected an Atlas E launch and two Soviet launches, finally proving the infrared early-warning system concept.

After a three-year hiatus for further design and development, *Midas* follow-on launches resumed in the summer of 1966.[8,9] Three missions were launched from SLC-3E, all using the Atlas SLV/Agena D vehicle. The June 9, 1966, launch was stranded in its elliptical transfer orbit because the Agena engine failed to fire. The launches of August 19, 1966, and October 5, 1966, were successful but apparently did not eliminate false alarms. Subsequent payloads were equipped with a television camera in addition to the infrared scanner so that ground control could identify clouds in the satellite's sensor range.[10] After the series of launches in 1966, the early-warning system was reoriented to geosynchronous orbit. None of the subsequent satellites were launched from SLC-3 or elsewhere on VAFB. By 1974, the early warning satellite system had evolved into the Defense Support Program (DSP) with capabilities for infrared and nuclear detection. Although the early warning system satellite program encountered many difficulties in its early years, the satellites launched from SLC-3E provided the basis for technology still in use today.

Environmental Research Subsatellites

During the period of early warning system launches from SLC-3E (1962 through 1966), environmental research subsatellites *(ERS)* were often launched as "piggyback" payloads along with the primary satellite. *ERS* satellites collected information about the condition of the primary satellite or carried engineering experiments to contribute to satellite design. *ERS 3* and *4* were part of the December 17, 1962, launch that failed to orbit. *ERS 5* and *6* were launched on May 9, 1963; both returned data about damage of the solar cells that powered the primary satellite. *ERS 7* and *8* were part of the June 12, 1963, launch that failed to orbit. *ERS 9* and *10* were launched July 18, 1963. *ERS 9* returned data about radiation damage of satellite systems; *ERS 10* failed to eject from the primary payload. *ERS 16*, launched on June 9, 1966, carried five metal-to-metal bonding experiments. The launch on August 19, 1966, carried *ERS 15*, which contained five cold-welding experiments.

SECOR-6 (launched June 6, 1966, with *ERS 16*) was a geodetic survey satellite that provided information on the shape of Earth and variations in its gravitational and magnetic fields. Information produced by geodetic subsatellites was vital to improving the precision and accuracy of U.S. ICBMs. *EGRS 7*, launched on August 19, 1966, and *EGRS 8*, launched on October 5, 1966, also were part of a geodetic package. The subsatellite concept continued in the SLC-3E launch of August 16, 1968, which consisted of ten subsatellites. Various subsatellites were designed to investigate materials handling, radar calibration, geodesy, gravitation, infrared background, and shortwave radiation; however, they all failed to orbit.[11]

Classified Payloads

Most payloads launched from SLC-3 between 1961 and 1972 remain classified. Many of the classified payloads launched from SLC-3 were second and third-generation satellites evolved from the *Samos* and *Discoverer* programs. The evolution of second-generation satellites was characterized by increased complexity of equipment and more features. Third-generation satellites had more complex electronics, multiple functions, and were considerably heavier than second-generation satellites. The second-generation satellite period was between June 1964 and March 1967. The third-generation satellite period was from 1968 to 1972.

Sixteen classified payloads were launched from SLC-3W during the second-generation satellite period; all used Thor vehicles. The development of the thrust-augmented Thor (TAT) (launched from SLC-3W between 1963 and 1972) with its three solid-fuel engines made it feasible to have launched the larger second-generation satellites from SLC-3W. Nineteen classified payloads were launched from SLC-3W during the third-generation satellite period. Many used a combination of the long tank thrust-augmented Thor (LTTAT) and Agena D vehicles (table 3.2). The characteristics of LTTAT/Agena D combination allowed for a significantly heavier payload than could have been supported by earlier vehicles launched from the pad, making it possible for heavy payloads like the third-generation satellites to have been launched from SLC-3.[12] Most classified payloads launched from SLC-3W reached orbit (table 3.2); no other official information is available about those missions.

Precision Recovery Including Maneuverable Re-entry (*PRIME*)

The *PRIME* launches commonly are believed to have been associated with re-entry testing for the Space Shuttle; however, there may have been additional military objectives for the *PRIME* project. The *PRIME* program is notable in that its three payloads were the only nonorbiting payloads launched from SLC-3. The initial launch of an Atlas SLV booster in combination with a prototype *PRIME* spacecraft developed through the Lifting Body Technology Program occurred on December 21, 1966. The *PRIME* spacecraft was the flight element of the Spacecraft Technology and Advanced Re-entry Tests Program (START) conducted by the Air Force Space Systems Division. The dual objectives of the *PRIME* phase of the START program were to test new developments in space hardware and to explore the possibilities of developing future manned and unmanned lifting-body vehicles that could operate like spacecraft in orbit and like aircraft in the atmosphere.[13] Three launches from SLC-3E were associated with the program: the initial flight in December 1966 and subsequent flights on March 5, and April 19, 1967. The vehicle for all three launches was the Atlas SLV. All launches were considered successful.

Navigation System using Timing and Ranging (*NAVSTAR*) Global Positioning System (*GPS*)

Approved in 1973 during the administration of President Richard M. Nixon, *NAVSTAR* was designed to fulfill the navigational and positioning needs of all branches of the U.S. military forces. The *NAVSTAR* Global Positioning System provides a very accurate means of determining the position of objects anywhere on Earth. It consists of eighteen satellites configured in three rings circling the globe in a very high orbit. A system of twenty-four satellites was originally proposed for guaranteed twenty-four-hour global coverage. Radio signals are sent from the satellites to portable *NAVSTAR* ground receivers; the distance between the satellites and the location of a receiver is determined by the time it takes the radio waves to travel to the receiver. This GPS system is used not only for navigating ocean vessels, but also for directing the movements of aircraft and artillery units, field coordination and logistics, and target location. Military users achieve positioning information within 15 to 30 meters, velocity measurements within inches per second, and precise time referencing. These capabilities have applications for bombers, missiles, course correction, mission coordination, and operations at night and in adverse weather conditions. The portable *NAVSTAR* receiver,made by Rockwell International is also available for nonmilitary applications, such as search and rescue, shipping, and air traffic control; however, the positioning information provided to nonmilitary users is accurate only within 100 to 160 meters. SLC-3 was involved with the development and deployment of the *NAVSTAR GPS* between 1974 and 1985.

The Navy launched two navigational test satellites from SLC-3W in 1974 and 1977. The launch vehicle for both missions was the Atlas F. *Timation 3*, also called *Navigation Technology Satellite 1 (NTS-1)*,[14] was launched on July 13, 1974; *NTS II*, a *NAVSTAR* precursor, was launched on June 23, 1977. Control of the navigational program switched from the Navy to a multiservice effort, over which the USAF has primary responsibility. The next seven *NAVSTAR* payloads, designated *NAVSTAR Navigational Development Satellites (NDS)*, were launched from SLC-3E between February 22, 1978, and December 18, 1981. All were successful, except the last, which had to be destroyed immediately after lift off. *NAVSTAR NDS 6* was the first navigational satellite that also was capable of detecting nuclear explosions.[15] The NDS designation was dropped after *NAVSTAR NDS 7* because the developmental phase was completed. *NAVSTAR 8* through *NAVSTAR 11* were launched from SLC-3W between July 14, 1983, and October 8, 1985. All four successfully reached orbit. Additional *NAVSTARs* were launched later in the 1980s, but SLC-3 was discontinued as the supporting pad because extra cladding added to the later versions made the payload heavier, necessitating the use of a launch vehicle with lifting capacity greater than that of the Atlas E/F series. The system was fully operational by the late 1980s, at several times the expected cost of $1.7 billion and with six fewer satellites than originally proposed for the system.[16]

Seasat and *Geosat*

SLC-3 has also supported launches of scientific research satellites such as *Seasat* sponsored by NASA, and *Geosat* sponsored by the U.S. Navy. *Seasat*, launched from SLC-3W on June 26, 1978 with an Atlas F/Agena D launch vehicle, was the first satellite designed specifically to monitor the ocean by radar altimetry. The solar-powered research satellite was intended to circle the Earth in a 500-mile orbit and provide worldwide scientific ocean surveillance for one to three years. The satellite stopped functioning after less than four months in orbit, however, because a short circuit drained power from the batteries. Although this mission ended prematurely, the scientific data collected were invaluable to the scientific community. *Seasat* supplied radar images of many ocean features including sea ice, currents, eddies, and waves. Microwave sensors were also used to measure sea temperatures and wave heights (related to the depth of the ocean floor) from which wind speed and direction could be determined. These data made it possible to make topographic maps of remote areas of the ocean and to analyze ocean-generated storm systems. *Geosat* was designed to generate additional gravitational data originally expected from *Seasat*. Developed by The Johns Hopkins University, *Geosat* was launched from SLC-3W using an Atlas E booster on March 12, 1985, nearly seven years after *Seasat*. A geodetic satellite, *Geosat* measured variations in the Earth's surface and the resulting gravitational variations. It is believed that the data collected during this mission, in addition to purely scientific interest, were also used for improving the accuracy of submarine-launched missiles.[17]

NOAA/*TIROS* Weather Satellites

NASA and NOAA jointly operate the National Weather Service meteorological satellite system that transmits daily global weather information to users around the world. The information provided by the system includes surface cover and cloud cover pictures, surface and atmosphere temperatures, humidity, and many other atmospheric parameters used in weather forecasting. Weather observation and monitoring satellites used today evolved from the television and infrared observation satellite (*TIROS*) program of the early 1960s, which transmitted cloud cover photographs and data about heat reflected from the Earth. The early launches were highly successful, and the payloads became increasingly complex throughout the 1970s as more sophisticated instrumentation was incorporated. Additional capabilities included day and night data collection and tape-recorded or direct transmission of information.

The *Advanced TIROS-N* (ATN) meteorological satellite was the first weather satellite launched from SLC-3. This satellite, launched from SLC-3W in 1978, was a research and development spacecraft that was a prototype for the third-generation operational system: *NOAA A* through *H*. This series was similar to previous *TIROS* satellites but had additional sensing devices for monitoring more atmospheric parameters with higher resolution. Some NOAA payloads were also equipped with international search and rescue equipment. There were nine launches (*NOAA A* through *NOAA H*) of NOAA weather satellites from SLC-3W between May 29, 1980, and May 14, 1991, including the *TIROS N* prototype. Of the twelve NOAA satellites currently in orbit, seven (*NOAA 6* through *NOAA 12*) were launched from SLC-3W.

The *NOAA A* through *H* series of satellites were designed by RCA Astro-Electronics (now GE Astro-Space) using the same technology used in the USAF's Defense Meteorological Satellite Program. The NOAA system consists of two satellites in sun-synchronous orbits: one in a morning orbit and one in an afternoon orbit. From these orbits, the Earth's surface can be seen at least twice by each satellite during a twenty-four-hour period. The satellites can receive, process, and retransmit data from global stations. An operational lifetime of approximately two years is expected, with a 350-year orbital life.[18]

TIROS N, launched from SLC-3W on October 13, 1978, was the prototype for the operational ATN series of meteorological satellites. *NOAA A* followed from the same pad on June 27, 1979. The NOAA satellites are designated with a letter before launch, and if launch is successful, they are redesignated with numbers. For example, *NOAA A* became *NOAA 6*, and *NOAA C* became *NOAA 7* in orbit. (*NOAA 1 through 5* were from an earlier phase of the program launched elsewhere.) *NOAA B* through *NOAA H* (11) were launched from SLC-3W between May 29, 1980, and May 14, 1991. *NOAA D* (12) was actually the last satellite of the program launched to date (May 14, 1991). All launches used Atlas E or F boosters. *NOAA B* did not achieve the desired orbit, and the satellite's orbit decayed on May 3, 1980; therefore it did not receive a number designation. The battery powering *NOAA E (8)* exploded on December 30, 1985, almost three years after launch. Although the operational life is only two years, most of these satellites remain in orbit with somewhat limited capabilities. Missions starting with *NOAA E* included equipment to support an international search and rescue system in addition to the standard meteorological and communications capabilities.

Defense Meteorological Satellite Program (DMSP)

The USAF maintains its own meteorological satellite system for supporting military activities and programs. Modern military (*DMSP*) and civilian (*NOAA*) meteorological satellites are very similar; both evolved from the *TIROS* program, both have RCA as the prime contractor, both use the same basic satellite technologies, and both have similar orbital characteristics. Much of the weather data collected is shared between NOAA and DMSP, and most of the information is also available to civilian and military users through portable terminals. Both systems consist of two satellites in sun-synchronous, near-polar orbit at approximately 500 miles. Because one of the pair of satellites is placed in a sunrise/sunset orbit and the other in a noon/midnight orbit, updated information is available every six hours. Satellites in both programs operate during the day and night and provide infrared and visible-light photographic images of the Earth. *DMSP* data can be stored on tape for transfer to the USAF Global Weather Center via ground stations, or the data can be transmitted continuously. Improvements dating from the late 1980s include satellite-to-satellite relay for quick distribution, of data, protection against jamming and antisatellite weapons, and the capability for inflight repairs.[19]

The DMSP was formed in 1971 or 1972; however, SLC-3 was not associated with the program until 1982. At that time, the launch vehicle was changed from the Thor to the Atlas to accommodate heavier payloads containing redundant systems that extend the operational life of the satellites to three years. All six *DMSP* launches since 1982 have been from SLC-3W. *DMSP 6* was the first satellite of the program launched from SLC-3 December 20, 1982. *DMSP 10*, launched from SLC-3W on December 1, 1990, is operational even though the desired orbit was not attained. It reportedly aided U.S. forces during Operation Desert Shield by providing information on cloud cover and sand storms.[20] *DMSP 11* was launched from SLC-3W on November 28, 1991, and additional support for the program will be provided from the pad as required.

Delivery Vehicles Launched from SLC-3

Several models of Atlas and Thor vehicles have been launched from SLC-3 throughout its history. Table 3.4 summarizes the periods during which various models were launched from each pad. Changes in the vehicles being launched and perquisite modifications in the configurations of the pads were driven primarily by the requirements of satellite programs; nevertheless, the vehicles themselves represent engineering advances in the aerospace industry that are worthy of note.

Atlas

The four models of Atlas launched from SLC-3 (i.e., D, SLV, E/F, H) share many common design features. The following general description of Atlas systems is based on E and F vehicles. The description provides background information necessary for understanding the current components and operations of SLC-3 and the various modifications of the launch pads. Available information on notable differences between the E/F and other models is discussed, focusing in particular on Atlas H, the last model launched from SLC-3E.

The Atlas F airframe (fig. 3.2) is a stainless steel and aluminum structure 10-feet in diameter and over 70-feet long comprising three sections. The adapter section connects the delivery vehicle to the space vehicle (payload). The tank section is a stainless steel, monocoque shell that provides tank space for approximately 30,000 gallons of propellants, structural support for the payload, and mounting points for all major subsystem components. The booster section consists of an aluminum cylinder, longerons, and a reinforced skin with nacelles and a fire shield of aluminum-fiberglass honeycomb. The Atlas F airframe weighs about seven tons when empty.

Table 3.4
Summary of Kinds Vehicles Launched From SLC-3

Pad	Type of Vehicle	Period	No. Launched
3E	Atlas D Atlas SLV Atlas E/F Atlas H	7/61-7/63 6/66-8/68 2/78-12/81 2/83-5/87	9 7 7 5
3W	Atlas D Thor[a] Atlas E/F	11/60-11/62 11/63-4/72 7/74-1994	9 37 26[b]+

[a] Several models of Thor were launched during this period, but the configuration of the launch pad did not have to be modified significantly to accommodate them.

[b] The four remaining Atlas E/F boosters will be launched from SLC-3W before the end of 1994.

The Atlas tank section consists of bands of stainless steel, 32-inches wide and 377-inches long, welded into a 10-foot diameter, 60-foot long cylinder that tapers at the forward end to connect with the payload adapter. The thickness of the cylinder wall ranges between 0.010 and 0.051 inches (approximately the thickness of a dime), depending on local stresses. The thinnest wall section meets a specification for minimum tensile strength of 200,000 pounds per square inch. A special cold-rolled austenitic steel (AISI grade 301) was perfected for the Atlas tank section, and new welding techniques and equipment were developed to fabricate it. The interior of the tank section is divided by a common bulkhead into separate compartments for the propellants. The top compartment contains approximately 18,300 gallons of liquid oxygen. A vent in the top compartment releases oxygen gas to maintain acceptable internal pressure in this compartment during the early phases of oxidizer loading. The lower portion contains approximately 11,400 gallons of RP-1 rocket fuel, which is a highly purified kerosene. The compartments are pressurized with helium at all times, because the tank section is not rigid and cannot support its own weight. When the vehicle is erected to vertical orientation on the launch pad, a stretch mechanism ("stretch sling") that applies a 10,000 pound load is attached to the vehicle to maintain its rigid structure in the event of loss of pressure. Two equipment pods containing electronic units are attached to the tank skin (fig. 3.2). A long pod houses autopilot and

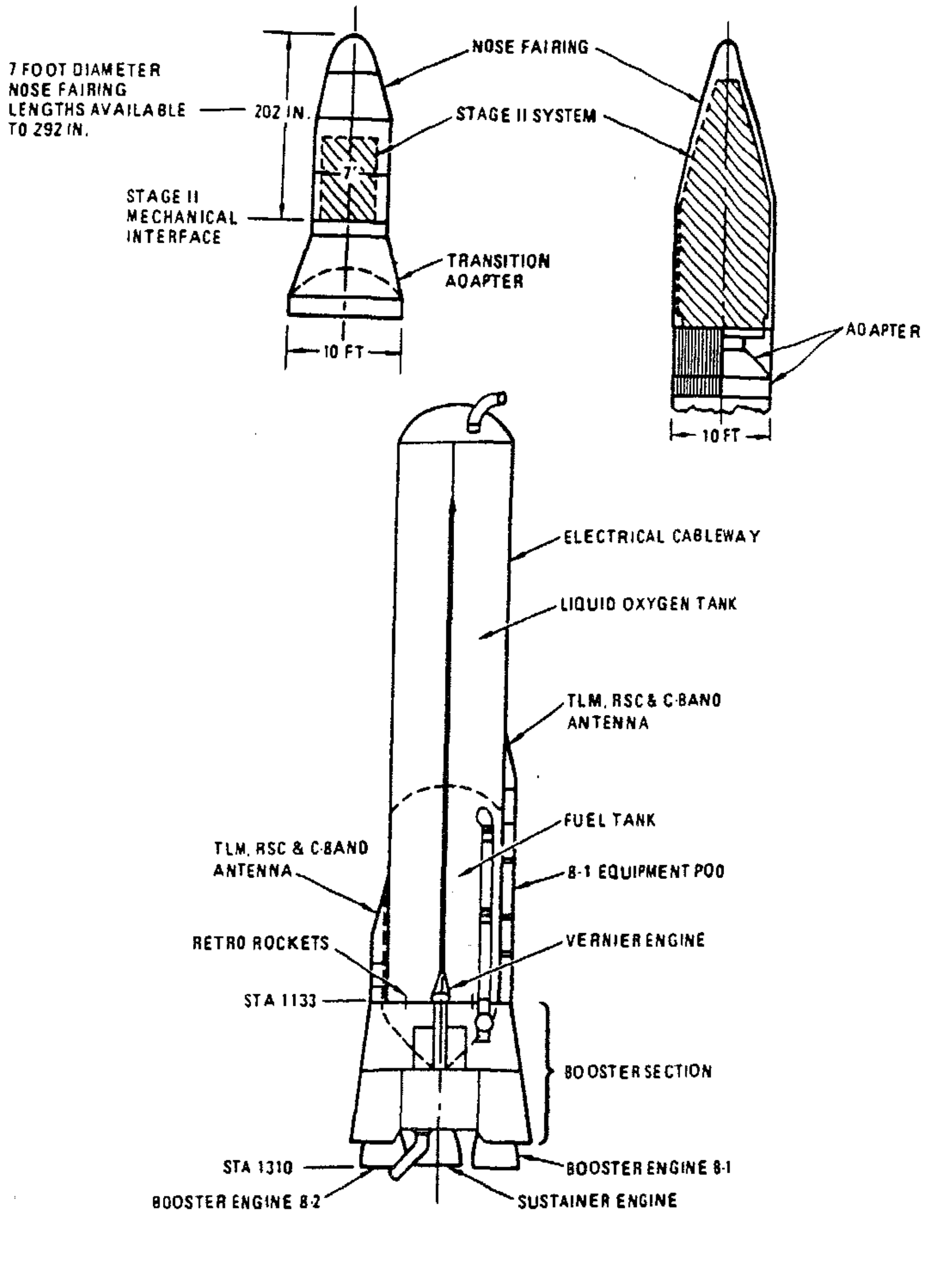


Fig. 3.2. Atlas vehicle configuration

telemetry equipment, and the vehicle's airborne electrical power supply (main missile battery); a short pod houses radio guidance equipment.

The Atlas E/F is powered by five engines: one sustainer engine, two booster engines, and two vernier engines. In a unique system first proposed by Convair in 1949, all five Atlas engines are ignited prior to launch. Missiles developed prior to the first Atlas typically had two "stages"--one mounted on top of the other. The bottom stage furnished all power until it burned out; then, it jettisoned and the second stage ignited. The Atlas propulsion system, known as "the one and one-half stage principle," eliminated the risk of an aborted flight if the second stage failed to ignite. The Atlas sustainer and vernier engines are gimballed, providing control of the flight attitude of the vehicle. The booster engines cut off and are jettisoned approximately two minutes after launch (fig. 3.3). The sustainer engine continues to accelerate the vehicle until it has attained a velocity of approximately 16,000-statute miles per hour; the sustainer engine cuts off approximately five and a half minutes after launch. After the sustainer engine cuts off, the small vernier engines continue for several seconds and may be used to trim the velocity of the vehicle to the exact value required for appropriate placement of the payload. The payload, or space vehicle, separates from the Atlas tank section shortly after the vernier engines cut off. The space vehicle may have an independent propulsion system (i.e., a "second stage" such as the Agena) for achieving orbit or for repositioning the payload once in orbit.

A transfer system pressurized with gaseous nitrogen is used to load propellants from ground storage tanks located near the launch pad into the vehicle's tanks. Gaseous nitrogen is stored in high-pressure bottles at 2,200 psig. Fuel from a 15,000-gallon storage tank is loaded aboard the vehicle one day before launch. After the vehicle's fuel plumbing is checked for leakage, personnel are cleared to a safe distance, and the vehicle's fuel tank is pressurized to flight pressure for five minutes. Then, the tank is vented to "standby" pressure, and the system is checked a second time for leaks. After the second leak check, fuel is drained below 100 percent until approximately two hours prior to launch. The vehicle's fuel tank is topped to 100-percent capacity just prior to loading the liquid oxygen. Liquid oxygen is stored in two 28,000-gallon, double-walled, insulated storage tanks (i.e, the "rapid load" and "topping" tanks). Liquid oxygen is loaded in three phases: chilldown (i.e., the tank is cooled by the liquid oxygen until it no longer boils off upon entering the tank), rapid load, and topping. During chilldown and rapid load, liquid oxygen is transferred from both storage tanks simultaneously. When the vehicle's tank is 99.25-percent full, the rapid load tank is isolated and vented. From this point until countdown, the liquid oxygen continuously boils off and is replaced from the topping tank to maintain approximately 99.25-percent capacity in the vehicle's tank.

Atlas vehicles are equipped with a pneumatic system for maintaining appropriate internal pressures in the compartments of the tank section. The primary function of the system is to maintain adequate inlet pressures for the propellant pumps to prevent cavitation during flight. Helium was selected as the gas for the Atlas pneumatics system because of its chemical stability,

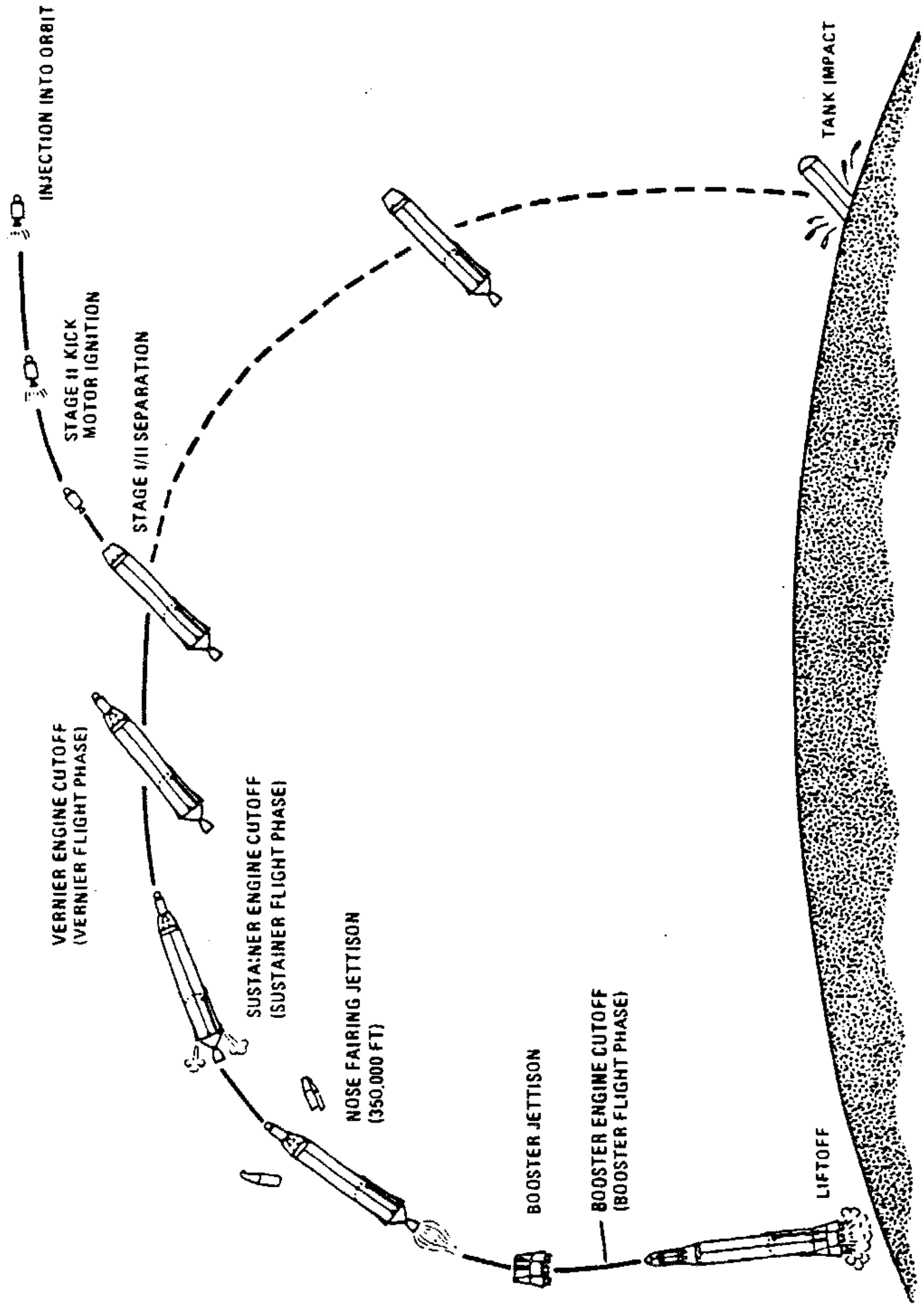


Fig. 3.3. General Atlas flight profile showing various flight phases

low specific weight, and desirable thermodynamic properties (i.e., very low critical temperature). Helium to supply the Atlas during flight is stored as a liquid in five bottles in the booster section. Helium is transferred from high-pressure (approximately 6,000 psi) storage bottles located near the launch pad into the booster bottles via a heat exchanger that uses liquid nitrogen to condense the helium gas. The space saved by refrigerated storage of helium is approximately three to one. The liquid helium is heated and expanded in a turbine heat exhaust exchanger in the booster section of the Atlas vehicle. The stored helium performs several secondary functions in addition to maintaining flight pressures in the Atlas propellant compartments. It is used to operate propellant valves on the vernier engines, purge the turbo pump seals, and actuate staging valves that separate the booster section from the tank section.

Another important component of an Atlas vehicle is the propellant utilization (PU) system. The system has both ground and airborne components. The ground component of the PU system is described in detail in Chapter 5. The airborne component of the system is the propellant utilization control unit (PUCU), which adjusts the mixture of fuel and liquid oxygen reaching the sustainer engine to achieve maximum engine performance and minimize the volume of residual propellants when the sustainer engine cuts off. Without a PU system, the many variables affecting propellant flow could cause one propellant to be consumed before the other, resulting in many hundreds of pounds of residual propellant. Large residuals reduce vehicle performance because they are "dead weight." The PUCU is a digital flow-control system that determines the ratio at which propellants are being used and adjusts the ratio to the proper value during flight. The propellant ratio is sampled at seven discrete points during flight.

Atlas vehicles are equipped with a hydraulic system that supplies pressurized hydraulic fluid for engine gimballing and for operating valves in the sustainer engine. The system has both ground and airborne components. The ground component consists of a hydraulic pumping unit (HPU) that supplies high-pressure hydraulic fluid to the vehicle prior to launch. The airborne component comprises three subsystems: the booster hydraulic system, which positions the thrust chambers during flight; the sustainer-vernier system, which controls the flight attitude (pitch, yaw, and roll) of the vehicle after the booster section is jettisoned; and the vernier-solo system, which controls the flight attitude of the vehicle after the sustainer engine cuts off. Hydraulic pumps driven from the accessory drive pads of the engine turbopumps provide hydraulic pressure to the actuating cylinders. During their solo phase, the vernier engines are actuated by hydraulic pressure stored in vernier-solo accumulators. Control orders are received from the flight control system (autopilot) and are translated from electrical to hydraulic commands by servo control valves mounted on each actuator.

The Atlas autopilot is an inertial guidance system that uses displacement and rate gyroscopes located in one of the equipment pods mounted on the airframe to monitor and control the flight attitude of the vehicle. The system has both ground and airborne components; the ground component of the autopilot system is described in Chapter 5. Three displacement gyroscopes provide inertial reference in the pitch, yaw, and roll axes; sense angular displacement around the reference axes; and produce appropriate error signals. Three rate gyroscopes sense the vehicle's angular velocity around the reference axes and produce appropriate error signals. The autopilot servo accepts error signals from the gyroscopes, accepts position feedback signals from the vehicle's engines, produces engine control signals (i.e., signals to the hydraulic system that controls engine gimballing), and activates and deactivates engines for the various flight phases as directed by the autopilot programmer. The autopilot programmer provides timing and wiring (logic) for commands to enable or disable the engines, accepts engine cutoff commands from the autopilot's ground component, and produces a new time reference for subsequent events under its control (e.g., fairing separation, pyrotechnic currents for jettisoning the booster section). The autopilot programmer is capable of timing events at one-tenth second intervals.

Atlas vehicles are also equipped with a radio guidance system, the General Electric Radio Tracking System. Once again, this system has both ground and airbome components. Much of the control and monitoring of this system takes place outside SLC-3 and is not considered in this description. The ground components of this system that are located on SLC-3 are described in Chapter 5. Atlas vehicles carry a pulse beacon and antenna that emits a c-band pulse upon receipt of a valid X-band, fourteen pulse message from a ground tracking station located outside of SLC-3. After the return pulse is sent, circuitry within the airborne pulse beacon temporarily deactivates the receiver to prevent unauthorized tracking of the vehicle.

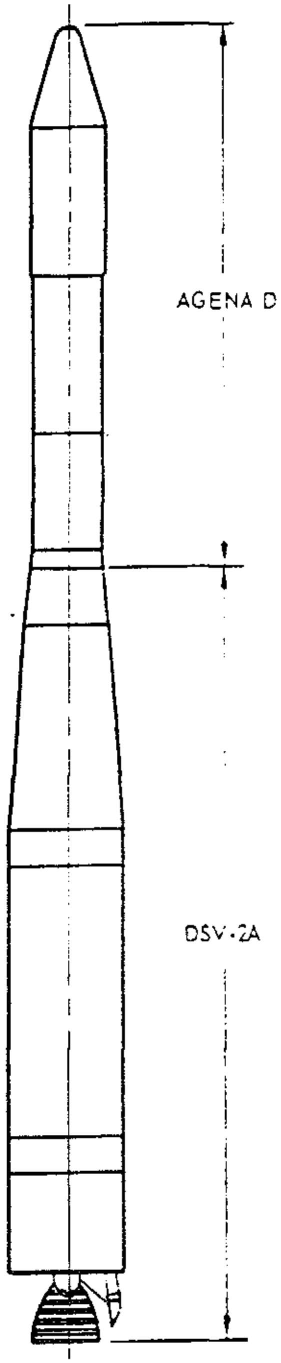
For the purpose of highlighting significant differences in design, the Atlas vehicles launched from SLC-3 can be considered in two groups: Atlas D, SLV, and H constitute one group; and Atlas E and F constitute the other. The members of each group are similar or identical to each other and are different from the members of the other group. The most significant differences between the groups include the number of engines, the degree of electrical control required, and the nature of the launch. Atlas SLV and H had only one booster engine with two thrust chambers; whereas, Atlas E and F have two booster engines. In Atlas E/F and H, the engine valves are operated by fuel pressure instead of pneumatically; therefore, fewer electrical signals are required for these models than for the SLV, and the ground electrical systems at SLC-3E were greatly simplified. Atlas E and F vehicles are free launching; Atlas D, SLV, and H all were equipped with a hold-down mechanism that anchored the vehicle to the pad until all engines had achieved 90-percent thrust. Atlas D, E, and F vehicles were decommissioned ICBMs; whereas, Atlas SLV and H vehicles were constructed specifically for space launches. Atlas H was designed in response to a military payload sponsor's concern about reliability of the Atlas E/F.[21] Several E/F missions had been aborted in flight due to the failure of one or more engines to ignite prior to free launch. The Atlas H was designed to combine desirable features of the E/F model with the reliability of the hold-down system. Other more specific differences between Atlas E/F and H are described in Chapter 5 where they pertain to specific features of SLC-3E or its control room in the Launch Operations Building (Blockhouse, Bldg. 763).

Thor

For approximately ten years between 1963 and 1973, SLC-3W was configured to launch Douglas Aircraft Corporation's Thor vehicles. Thor was used so extensively in both the military and civilian space programs that it was dubbed the "Workhorse of the Space Age." Several models of Thor were launched from SLC-3, including the Thrust Augmented Thor (TAT), Thorad (Long Tank Thor), and the Long Tank Thrust Augmented Thor (LTTAT). The augmentation of the basic Thor vehicle typically consisted of the addition of several solid-propellant rocket boosters to enable the Thor to deliver heavier payloads into orbit.

As previously mentioned, many features of early Thor design were derived from work already in progress on the Atlas. The Thor was known as a "half-Atlas;" it used only one booster engine (one thrust chamber) instead of two and shared the Atlas nose cone and guidance system. Like Atlas, Thor also used RP-1 and liquid oxygen as propellants. Thor's sustainer engine was a pump-fed Rocketdyne MB-3, Block II model, and, like the Atlas, Thor had two small vernier engines to provide attitude control. The TAT had three Castor I solid-propellant rocket boosters strapped to the aft end of the vehicle. For the Thorad, the propellant tanks were lengthened, resulting in sixty-five seconds more burn time for the engines. The LTTAT had three Castor II solid-propellant rocket boosters.

Thor vehicles launched from SLC-3W were always used in combination with Lockheed's Agena upper stage. Recall that early experimentation with using Thor as a space delivery vehicle had employed as many as four stages. Figures 3.4 and 3.5 provide schematics of two Thor/Agena D vehicles typical of those launched from SLC-3W. A description of the modifications of SLC-3W required to accommodate Thor vehicles is presented in Chapter 5.



MODEL: DSV-2A
SYSTEM: Thor Agena D
SPONSOR: AIR FORCE
MISSION: Earth Orbiting Satellites
DESCRIPTION:

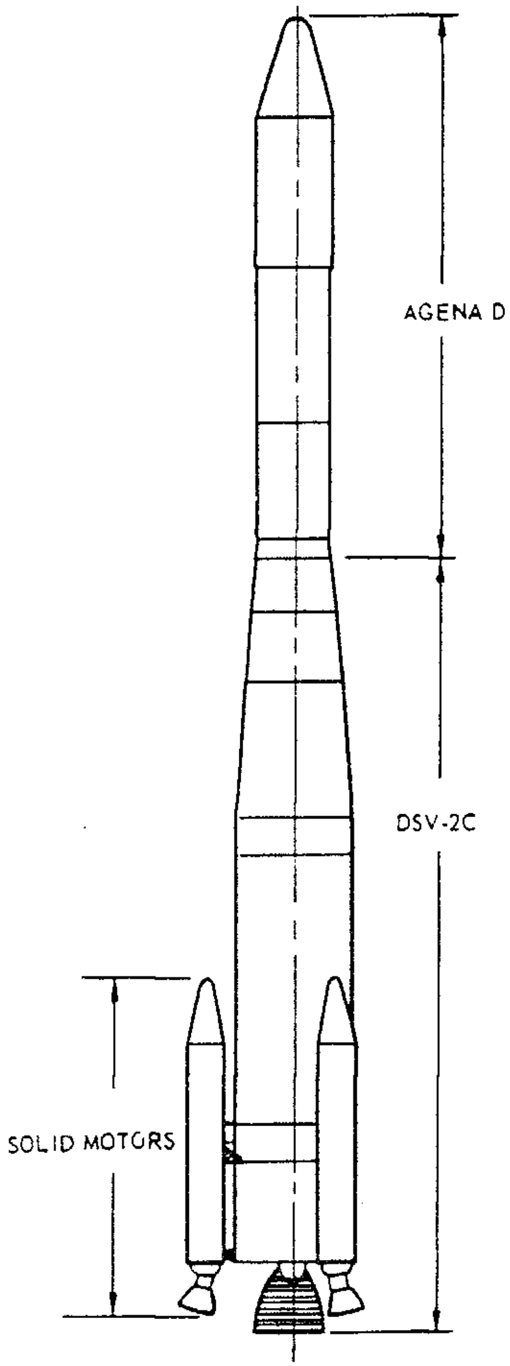
The DSV-2A has a transition section compatible with the Agena D. The propulsion system consists of an MB-3 Block II main engine, which produces a stabilized sea level thrust of 170,000 pounds, and two 1,000-pounds thrust vernier engines operate on liquid oxygen and RP-1.

The second stage is a Lockheed Model 30205 Agena D powered by a 16,000-pound vacuum thrust, Bell 8096, liquid propellant engine that burns hydrazine and red fuming nitric acid and has an inflight restart capability. Radio/inertial guidance, if employed, is located in the second stage.

PAYLOAD:
A.F. and NASA satellites

CONTRACTOR:
Prime - LMSC
First Stage - DAC
Second Stage - LMSC

Fig. 3.4. Typical Thor Agena configuration launched from SLC-3W



MODEL: DSV-2C

SYSTEM: Thor Agena D

SPONSOR: AIR FORCE

MISSION: Earth Orbiting Satellites

DESCRIPTION:

The DSV-2C is essentially a DSV-2A with three (3) Thiokol XM-33-52 solid propellant rocket motors mounted around the aft end of the airframe.

The solid motors are jettisoned after burn out at a time determined by range safety considerations.

Minor changes in the engine section structure and in the control circuitry have been made to accommodate the solid motors.

See description of DSV-2A for further information.

Fig. 3.5. Typical Thrust Augmented Thor/Agena configuration launched from SLC-3W

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CHAPTER 4

AN OVERVIEW OF SLC-3 FACILITIES AND OPERATIONS

Basic Features of Atlas Space Launch Complexes

Unlike the underground coffin and silo complexes designed for Atlas E and F ICBMs, early Atlas test complexes and all Atlas space launch complexes are vertical, surface structures with the following elements:

- A stationary launcher mounted on an elevated concrete pad (launch deck or launch pad) to support the vehicle

- A concrete "flame bucket" (flame or exhaust duct) directly beneath the launcher to channel rocket exhaust away from equipment on the launch deck

- A "launch services building" beneath the launch deck that contains control and monitoring equipment to support prelaunch vehicle preparations and testing

- A mobile gantry (mobile service tower or MST) with cranes for erecting the booster (delivery vehicle) and payload (space vehicle), and platforms at various levels that provide access to the delivery vehicle and payload for service and maintenance; the gantry is mounted on steel wheels that travel on rails in the launch deck so that it can be moved away from the launcher prior to the launch

- An "umbilical mast" or tower to support air-conditioning ducts and electrical connections (umbilicals) to the payload throughout the launch sequence; the mast remains in place after the gantry is moved away from the launcher and vehicle

- Fuel and oxidizer storage tanks with associated tubing, gauges, and pressurizing systems for transferring fuel, oxidizer, and inert gas into the vehicle propellant tanks; the storage tanks are located on ground-level "aprons" on either side of the launch deck

- A water deluge system on the launch deck and within the flame bucket to extinguish flames and muffle the sound of the launch; a concrete deluge channel directs the water away from the flame bucket, and the water is captured in a retention basin at the end of the deluge channel

- A "launch operations building" that contains equipment for remote control and monitoring of the launch; the building is usually a bunker positioned at a safe distance from the launch deck; several launch pads may share a launch operations building

The two Atlas launch pads at SLC-3 have A-frame gantries (photo. CA-133-1-B-2). This feature is shared by several other Atlas complexes constructed between 1956 and 1961 at Cape Canaveral and North VAFB. Complexes 11, 12, and 14 at Cape Canaveral were constructed for early testing of the Atlas. Complexes 576-A-1, 2, and 3 were Atlas D ICBM sites constructed at North VAFB; recall that the Atlas D weapon system was stored and launched vertically from the surface, as are Atlas space delivery vehicles. During the mid-1960s, complexes 576-A-1, 2, and 3 at North VAFB were used for space launches to support research on ballistic missile re-entry systems. These launch pads were renamed Advanced Ballistic Missile Re-entry System A (ABRES-A). Atlas launch pads designed and constructed after 1961 (e.g., SLC-4 at VAFB and Complex 36 at Cape Canaveral) do not have A-frame gantries.

The Atlas launch complexes at VAFB differ from those at Cape Canaveral in several ways. Fuel and oxidizer were transferred to vehicle propellant tanks by pumping at the Cape Canaveral complexes; whereas, the complexes at VAFB use nitrogen gas to pressurize the propellant transfer system. The two pads at SLC-3 have retractable umbilical masts that can be lowered into a trench in the launch deck. The masts can be partially retracted automatically immediately prior to launch to separate the umbilical cables and remove the mast from the delivery vehicle's drift envelope during launch. These are the only retractable umbilical masts at any U.S. space launch complex. Refer to Chapter 5 for complete descriptions of the structure and functions of specific features of SLC-3.

Most of the A-frame Atlas gantries discussed above have been demolished. The only three remaining are the two pads at SLC-3 and 576-A-1 in the ABRES-A complex on North VAFB. SLC-3W is still active and has Atlas E/F launches scheduled through 1994. SLC-3E was last configured to launch Atlas H vehicles. The pad has been inactive since 1987 and is scheduled for major renovation beginning in 1993. The pads at the ABRES-A complex were modified to support space launches of Atlas E and F vehicles in 1967; 576-A-1 has been inactive since 1989.

Overview of Typical Launch Operations at SLC-3

The sequence of operations involved in preparing for and executing a launch from SLC-3 described here is based on the current routine for Atlas E/F launches from SLC-3W. Although several different models of Atlas and Thor vehicles have been launched from SLC-3, the general prelaunch and launch routines were similar; therefore, the sequence described is representative of historical operations at SLC-3. Considerable work related to SLC-3 launches, including fabrication of parts and final assembly of the vehicle, occurs at other sites on VAFB; however, this description includes only the highlights of operations conducted within the perimeter fence surrounding SLC-3.

Prelaunch operations at the launch pad begin approximately forty-five days prior to the planned date of launch. See the appendix for an example of a "waterfall diagram" showing the sequence of prelaunch operations for a 1984 Atlas E launch. The exact sequence of operations may vary slightly according to the specific conditions of each launch; however, some generalizations can be made. Prelaunch operations fall into four categories: refurbishment and modification of the launch pad; testing, calibration, and check-out of mechanical and electronic equipment and systems; simulated flight and "wet dress rehearsal" of propellant loading systems; and final preparations for launch. Test data are formally evaluated at three points prior to launch corresponding to (1) completion of checkout procedures for systems and equipment such as propellant utilization ground equipment, launcher, umbilical mast, autopilot system, air-conditioning system, telemetry system, and radio guidance system; (2) completion of testing of the hydraulic systems, pneumatic systems, airborne propellant utilization control equipment, and the simulated flight; and (3) completion of the wet dress rehearsal. These data evaluations typically occur approximately thirty, fifteen, and ten days prior to launch, respectively. Some operations can occur simultaneously; others require completion of particular operations or must occur before certain other operations.

One major prelaunch operation throughout SLC-3 is configuring electrical wiring for all the control and monitoring equipment to mission specifications. This task involves wiring patch boards for all instrumentation in the appropriate Launch Services Building (Bldg. 751 or 770) and in the Launch Operations Building (Bldg. 763). Electrical wiring may begin several months prior to a planned launch; however, the schedule for this task depends in part on the frequency of scheduled launches. Because some launch control and monitoring equipment in the Launch Operations Building (Bldg. 763) is shared between the pads, electrical wiring may have had to be reconfigured rapidly during periods when both pads at SLC-3 were active and launching frequently.

Prelaunch operations on the launch pad begin with inspecting the pad, repairing any damage caused by the previous launch, and making any minor modifications required for the upcoming launch. While the pad is being prepared, the payload fairings (covers that encapsulate the satellite) are cleaned in the Vehicle Support Building (Bldg. 766) to remove any foreign objects (e.g., particles of dust, finger prints) that could interfere with payload instrumentation and are wrapped in plastic to prevent contamination. After cleaning, the payload fairings and adapters (figs. 4.1 through 4.4) are assembled to ensure proper fit. Prior to bringing the delivery vehicle to the pad, the alignment of the launcher is validated and adjusted, if necessary; its moving components are tested; and the propellant loading pressurization systems are checked for performance and leaks. Also prior to erecting the delivery vehicle, the hydraulic and pneumatic

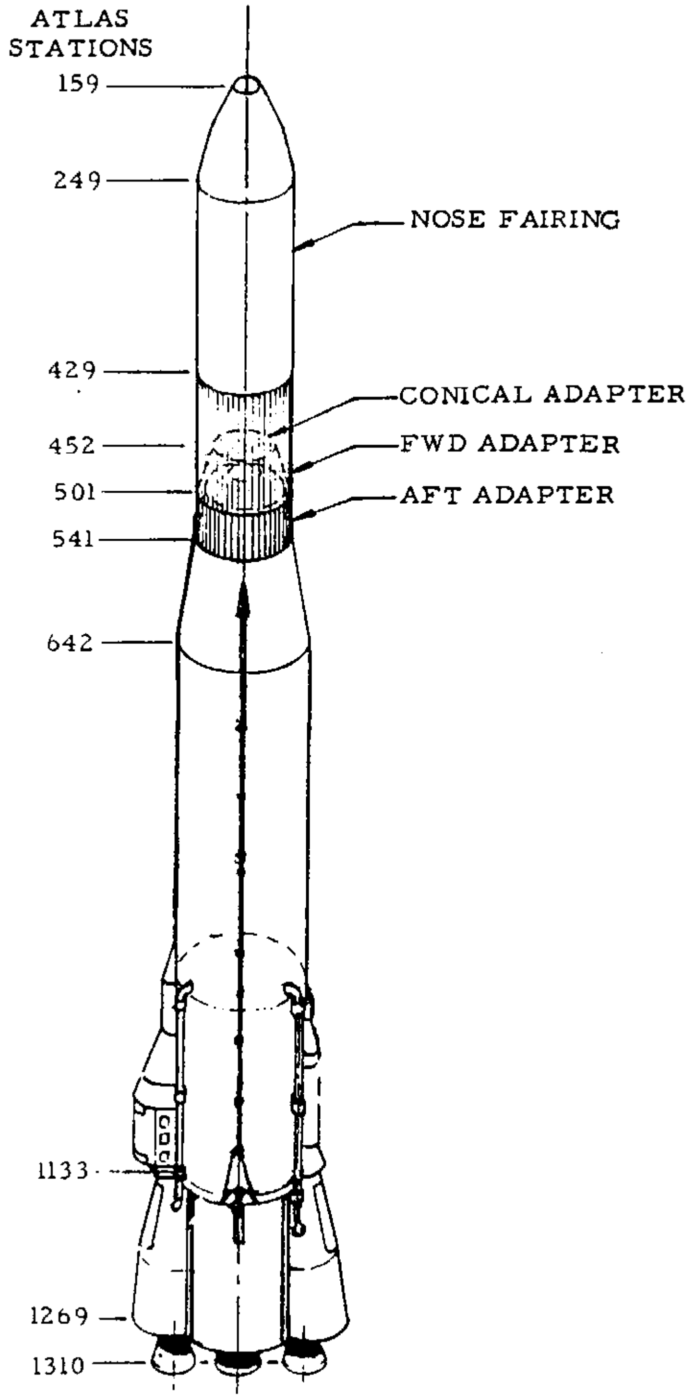
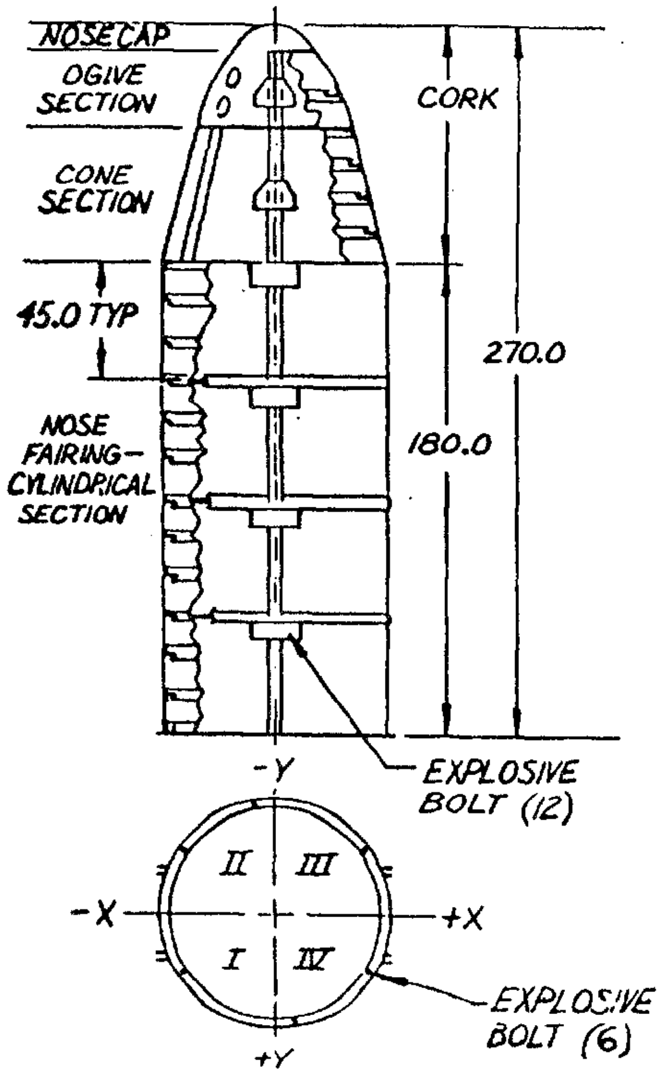


Fig. 4.1. Schematic showing payload fairing and adapters mated to an Atlas booster (*Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977.*)

FAIRING ASSEMBLY



DESIGN FEATURES

- MONOCOQUE SKIN FRAME CONSTRUCTION
- OGIVE SECTION STRETCH FORMED TO CONTOUR
- CYL SECTION EXTENDED 75-IN. (NOW 180-IN.)
- SHALLOW FRAMES IN PAYLOAD AREA (1.75)
- CENTAUR EXPLOSIVE BOLTS
- HORIZONTAL SKIN SPLICES
- ALL CUTOUTS & ACCESS OPENINGS BETWEEN FRAMES
- FINISH: INTERIOR - CHEM FILM
  EXTERIOR - EPOXY PRIME, WHITE POLY-URETHANE

Fig. 4.2. Schematic and design features of fairing assembly (*Source: General Dynamics Training Aid, no date.*)

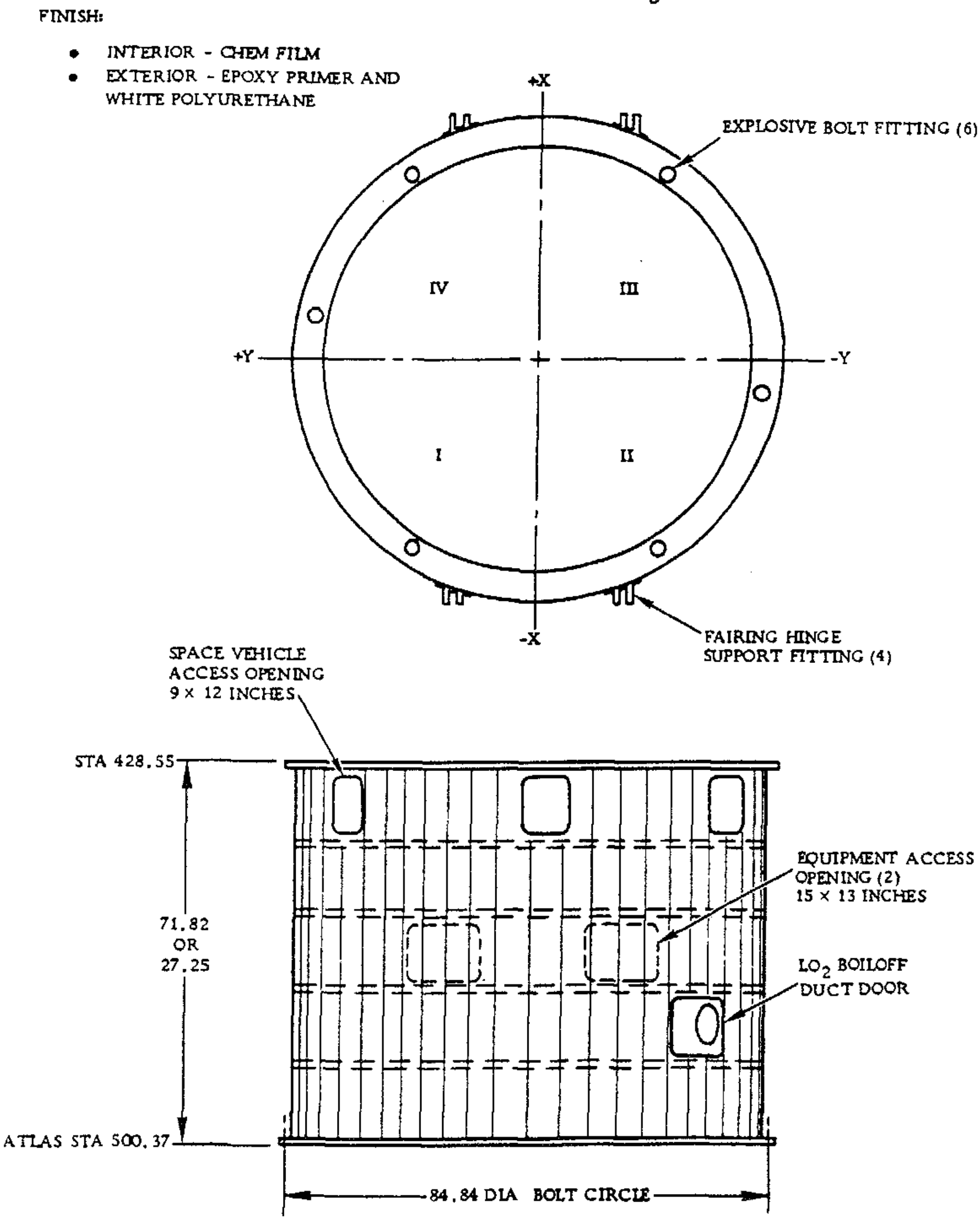


Fig. 4.3. Schematic of forward adapter showing fittings for explosive bolts (*Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicle System for Orbital Missions," December 1977.*)

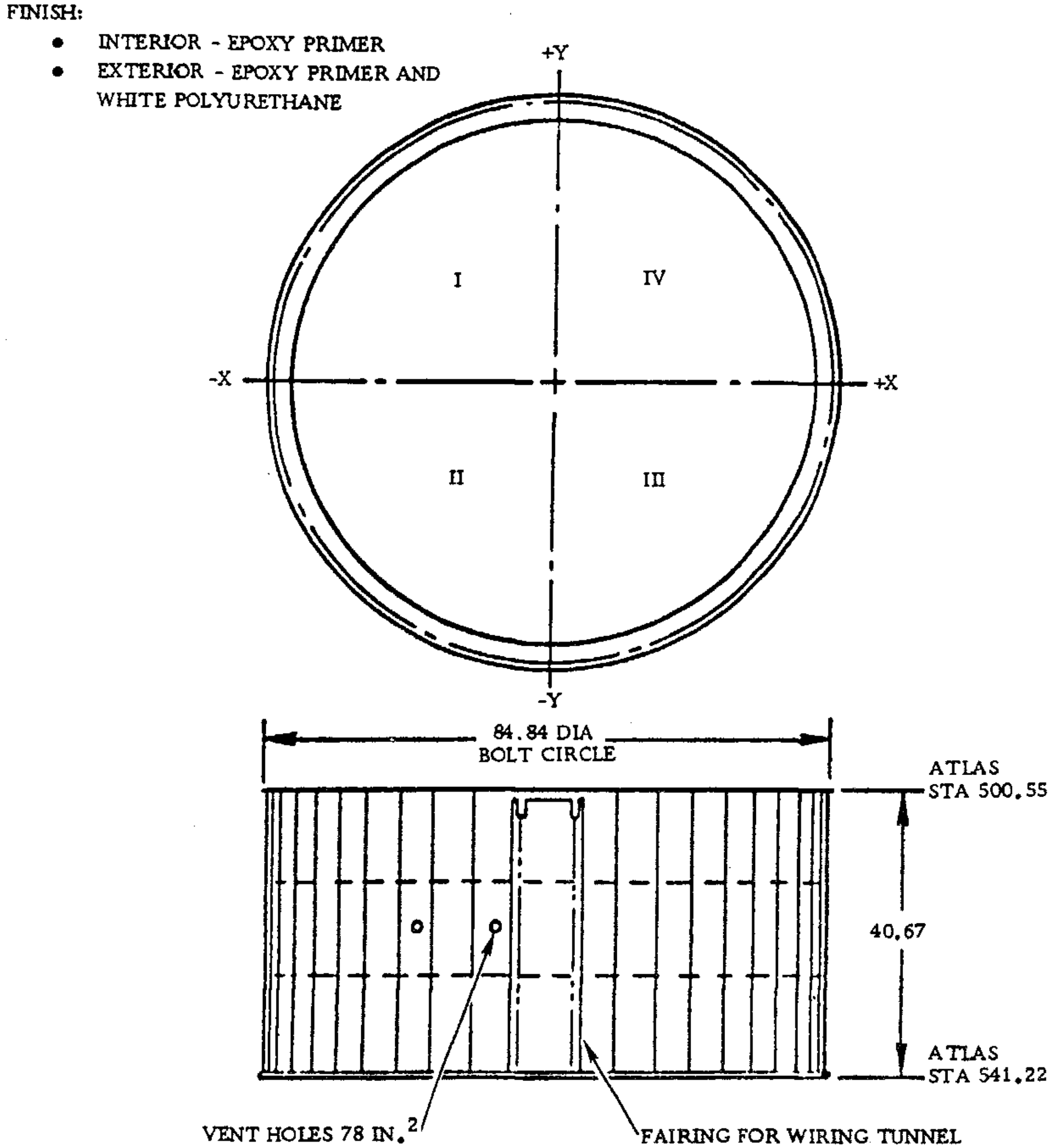


Fig. 4.4. Schematic of aft adapter
(*Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977.*)

components of the umbilical mast are checked for leaks; the trench doors and mast are operated to verify normal performance; and the "fast retract" mechanism for moving the mast and disengaging payload umbilicals is tested (fig. 4.5).

Once tests of the launcher and umbilical mast have been completed, the delivery vehicle can be erected into the mobile service tower (MST). The delivery vehicle is transported to the pad horizontally on a trailer. Upon arrival, it is mated to the launcher and erected using a screw jack associated with the launcher. At SLC-3W, newly erected Atlas E/F delivery vehicles are lifted using the bridge crane in the MST, rotated 180 degrees, and remated to the launcher. Rotation is required to align propellant line connection ports on the delivery vehicle with propellant lines on the launcher. At SLC-3E, which was last configured for Atlas H, the delivery vehicle was erected by raising the bed of the transport trailer using winches located at the top of the MST; the delivery vehicle did not have to be rotated after erection. Erecting the delivery vehicle also involves installing the propellant lines; attaching the stretch sling (fig. 4.6), which supports the delivery vehicle in the event of failure of the internal pressurization system that provides structural support for the delivery vehicle; and installing air-conditioning ducts and probes that service the delivery-vehicle levels of MST and the thrust-section heater duct. After the delivery vehicle is erected, the airborne pneumatic system, which replaces propellants with helium during flight to maintain nearly constant pressure in the propellant tanks, is checked out. The propulsion system is checked for leakage and normal functioning. During this series of tests, the empty payload fairing assembly is mated to the delivery vehicle. During the final preparations for launch, the fairing assembly will be equipped with pressure cartridges (explosive bolts, or "squibs") that are detonated during flight to separate the halves of the fairing, releasing the payload. When detonated, the squibs also activate the fairing separation actuator, which is a spring-loaded device that expands to fully separate the halves of the fairing (photo. CA-133-1-D-16; fig. 4.7). While the empty fairing assembly is mated to the delivery vehicle, the electrical system that relays the signal to detonate the cartridges is checked to see that the signal is strong enough and long enough to ensure detonation.

After the fairing ordnance has been checked out, the delivery vehicle undergoes two simulated-flight tests of its airborne systems. During the first simulated flight sequence, the landline instrumentation that connects the delivery vehicle to monitoring equipment in the Launch Services Building and Launch Operations Building is used to monitor guidance system operation, autopilot programmer commands, range safety system operation, and the responses of the flight control system (e.g., were sustainer and vernier engine cut-off commands generated at the appropriate time?). The second simulated flight sequence is conducted without the landline instrumentation so that only telemetry signals from the delivery vehicle are monitored. The data from these tests, which are recorded on strip charts and magnetic tape in the Launch Operations Building (Bldg. 763), are evaluated to identify any problems with systems on the delivery vehicle.

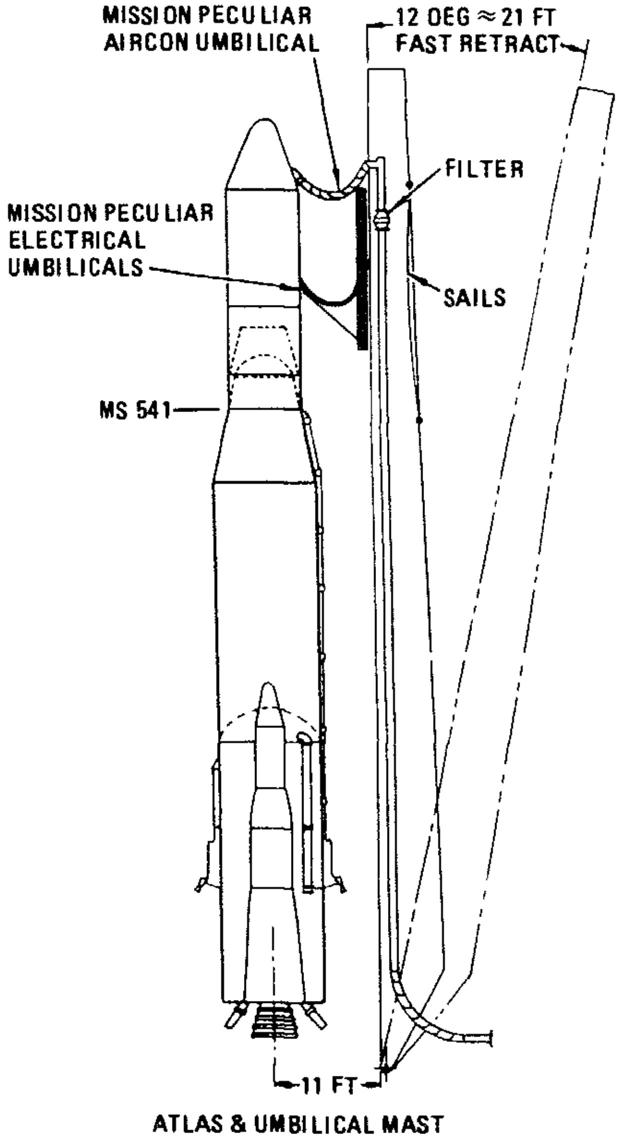


Fig. 4.5. Schematic showing "fast retract" capability of SLC-3 umbilical mast (*Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977.*)

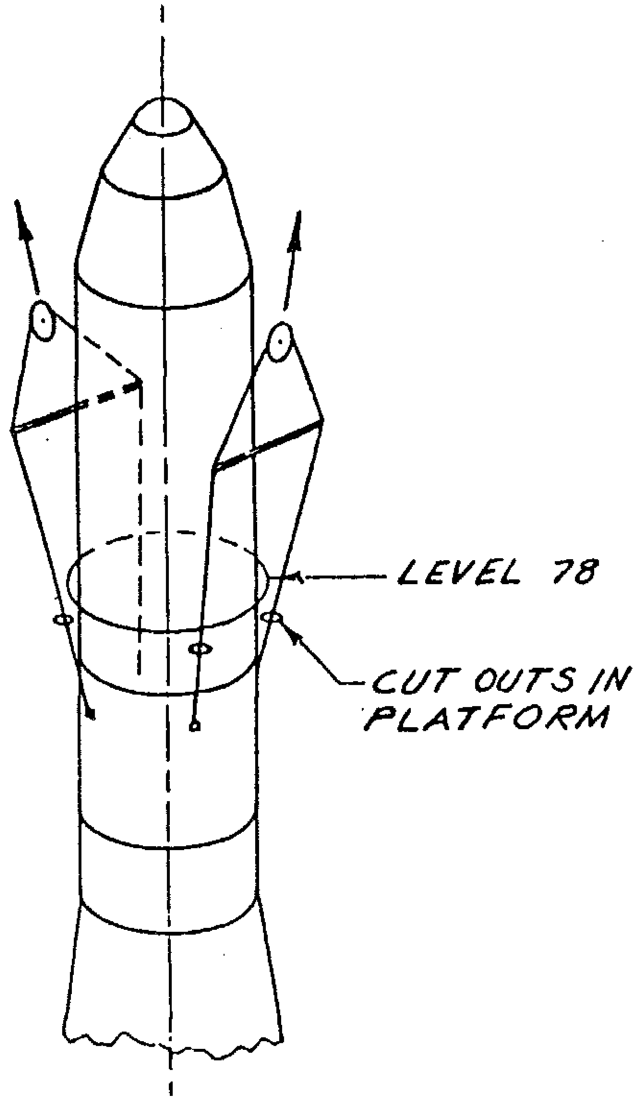


Fig. 4.6. Schematic showing installation of the stretch sling on an Atlas booster. "Level 78" refers to a service platform in the MST (Also see photo CA-133-1-B-25) (*Source: General Dynamics Training Aid, no date.*)

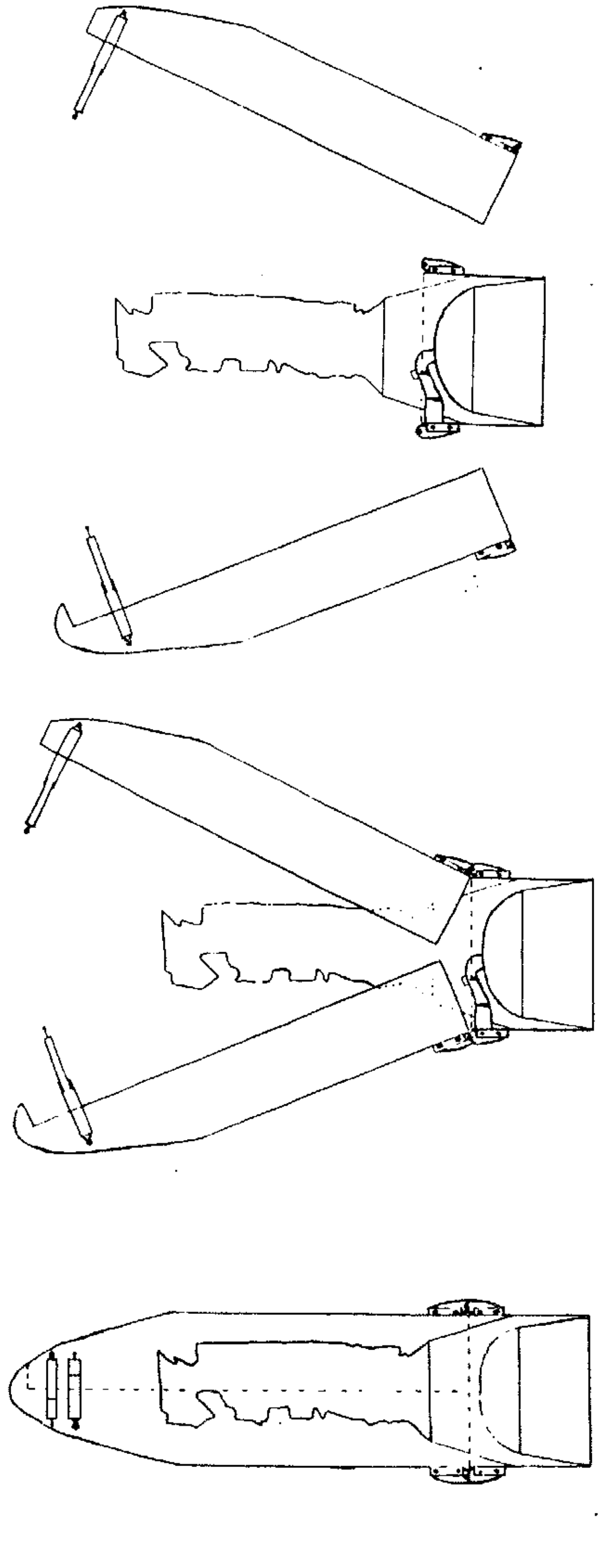


Fig. 4.7. Schematic showing operation of fairing separation actuators
(*Source: General Dynamics Training Aid, no date.*)

After the simulated flight tests have been completed, the fairing assembly is removed from the delivery vehicle and transported to North VAFB for encapsulation of the payload. While the payload is being encapsulated, the delivery vehicle is prepared for wet dress rehearsal of propellant loading. Preparations of the aerospace ground equipment (AGE) include verifying the availability of ground power and remote control capability; verifying the positions of valves and adjusting manual loaders in the propellant loading system; verifying the levels of propellants in the fuel and liquid oxygen storage tanks and the pressures in the gas storage tanks; calibrating the landline recorders; and performing limited functional tests of the propellant utilization, propulsion, and airborne pneumatic systems. Preparations of the delivery vehicle include installing fuses to simulate engine pyrotechnics and visually verifying electrical connections. When all preparations are complete, fuel is loaded into the delivery vehicle tank, the fuel system is checked for leaks, and the countdown sequence is rehearsed (refer to the description of equipment and functions of the Launch Operations Building in Chapter 5 for a description of the countdown sequence). After the wet dress rehearsal, propellants are drained from the delivery vehicle, the pad is secured, and data are evaluated.

Following evaluation of data from the wet dress rehearsal, final preparations for launch begin. These preparations repeat those described above for the dress rehearsal with the following additions: verifying adjustment of the destruct monitor circuits; installing batteries and pyrotechnics; securing the thrust-chamber boots; loading fuel; and installing the Bullova destructor, which is an explosive charge mounted on the diaphragm that separates the fuel and oxidizer compartments. The encapsulated payload is mated to the delivery vehicle, and a flight readiness test similar to preparations for the simulated flight is completed. At this point, the mission is ready to be launched.

Launch operations (the countdown and commit sequences) are controlled and monitored from the appropriate control room in the Launch Operations Building (Bldg. 763), as described in Chapter 5. After launch, telemetric flight monitoring at the Launch Operations Building continues for approximately one minute before the vehicle moves out of range of SLC-3; telemetric monitoring continues at several remote range telemetry stations, as described in Chapter 5. After launch, propellant and gas transfer lines are purged, electric power to the pad is disconnected, and the umbilical mast and MST are washed down. The pad is surveyed for damage caused by the launch and required repairs are recorded in a log. Extraordinary damage may be photographed.

CHAPTER 5

DESCRIPTION OF SLC-3 STRUCTURE AND FUNCTION

Space Launch Complex 3 is a 40-acre complex (fig. 5.1; photos. CA-133-1-1, 2, 7, 15) that originally consisted of two launch pads with open-frame mobile service towers; a 41,384-square-foot, earth-covered Launch Operations Building (LOB; Bldg. 763); a 2,613-square-foot Vehicle Support Building (Bldg. 766); a 10,320-square-foot Complex Service Building (now called Technical Support Building; Bldg. 762); a 2,628-square-foot Technical Support Building (now called SLC-3 Air Force Building; Bldg. 761); three 48-square-foot traffic check houses; four 36-square-foot theodolite shelters; and a "package" sewage treatment plant. The entire complex was surrounded by a 6-foot high security fence topped with barbed wire. Except the concrete LOB and the launch pads, all structures are sided with sheet metal. Original plans for the complex included two additional launch pads (photo. CA-133-1-15); however, these were never constructed. The most prominent features of SLC-3 are the two mobile service towers (photos. CA-133-1-5 through 7, 9 through 11). These towers were originally open frameworks of steel girders, beams, and cross braces. Over the years, the frameworks were covered with sheet metal and large hydraulically operated doors enclosing the north and south faces (photos. CA-133-1-2, 4 through 6, 13, 14). Above-ground cable trays connect the LOB with each launch pad (photo. CA-133-1-10).

As military space mission requirements expanded, so did SLC-3. In 1964, the Launch Operations Building (Bldg. 763) was expanded 50 percent to provide separate control rooms for each launch pad (fig. 5.2). The Complex Service Building (Bldg. 762) received a 648-square-foot expansion in 1965 to increase office space, and the SLC-3W Launch Services Building (Bldg. 770) received an Agena checkout and transfer facility encompassing 2,493 square feet. The most significant changes to the complex occurred in 1976 with the addition of several new buildings (fig. 5.3). A 7,200-square-foot building was relocated from ABRES-A and attached to the Complex Service Building (Bldg. 762; photo. CA-133-1-3, and 4). A 672-square-foot storage shed (Bldg. 773) relocated from ABRES-A was placed near the sewage treatment plant. An identical storage shed (Bldg. 776) was constructed on SLC-3E. A 358-square-foot, concrete block Pyrotechnic Storage and Testing Shed (Bldg. 757) was constructed north of Building 776, and an asphalt road was built to connect the two buildings. The Global Positioning System Azimuth Alignment Shed (Bldg. 775) was constructed a year earlier in 1975. The entrance to the complex was modified so that access to the administration area (Bldgs. 761 and 762) was no longer restricted. The two small traffic check houses, Buildings 760 and 764, were demolished, and a concrete block Gate House (now called Entry Control Point; Bldg. 768) complete with electrically operated gates was constructed in front of the LOB. The perimeter fence was extended to enclose SLC-3W and the LOB. In 1977, sheet-metal theodolite shelters, Buildings 786 and 788, were constructed adjacent to each launch pad. Both theodolite shelters

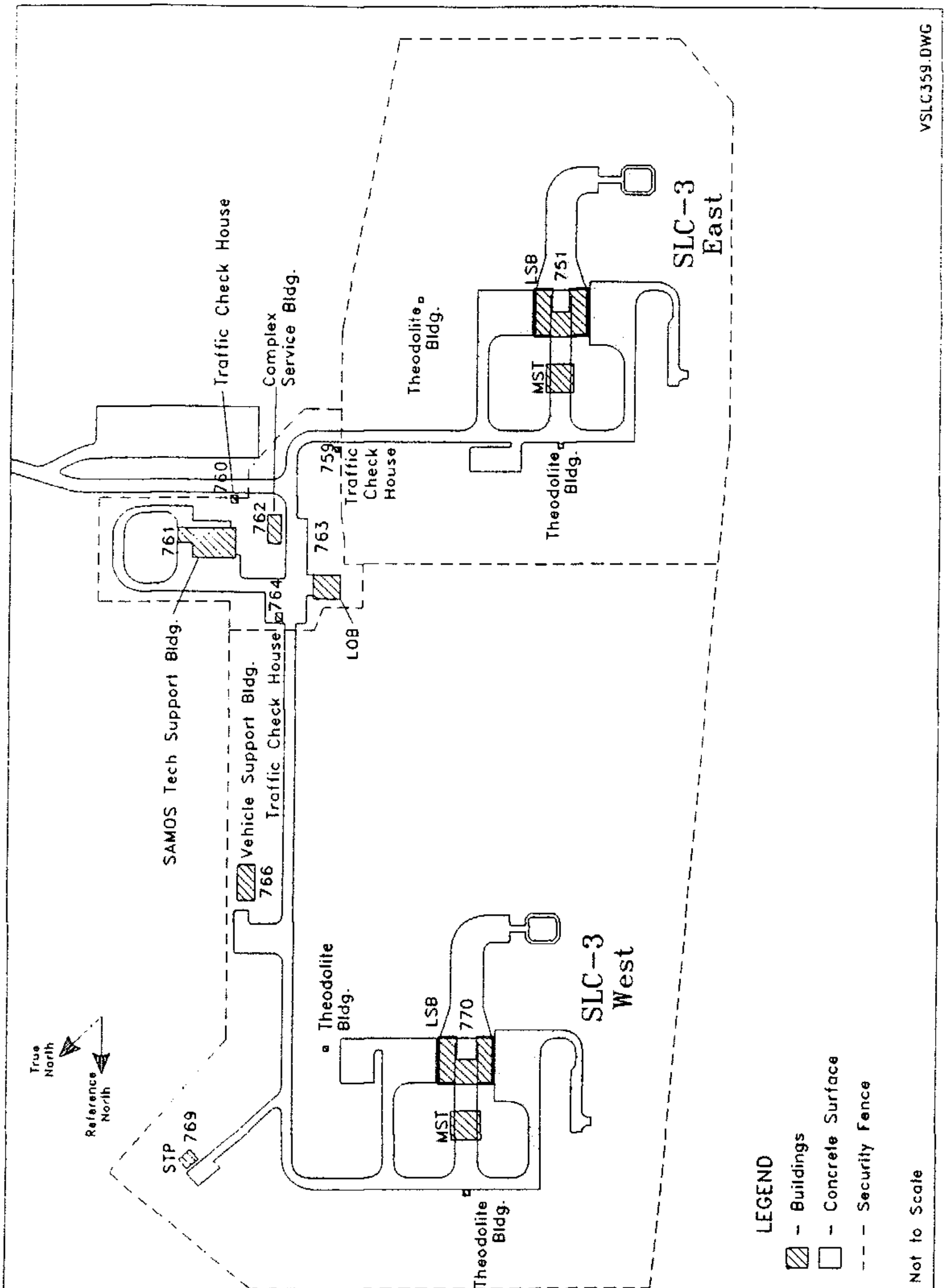


Fig. 5.1. Space Launch Complex 3, 1959 configuration

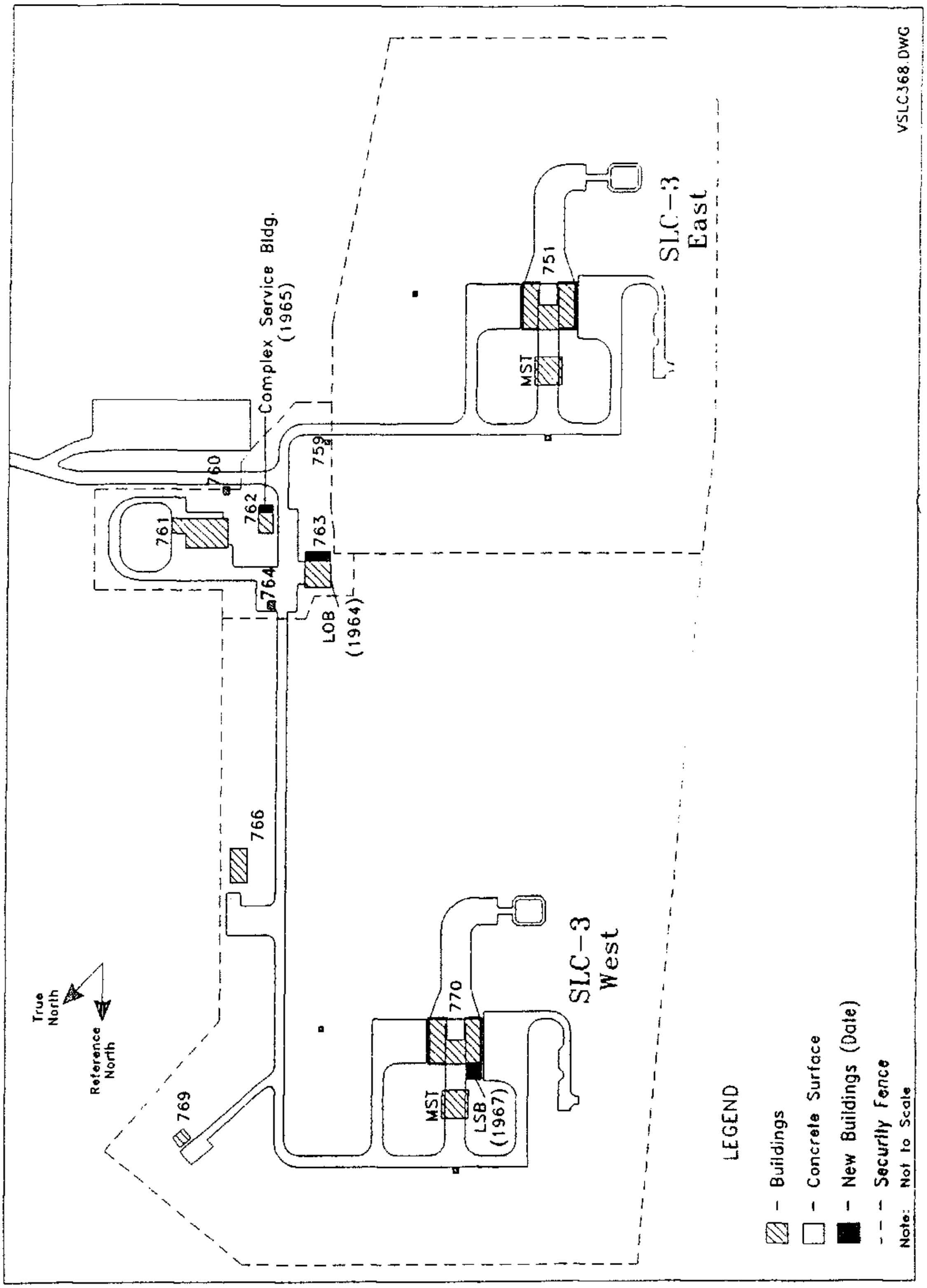


Fig. 5.2. Space Launch Complex 3, 1968 configuration

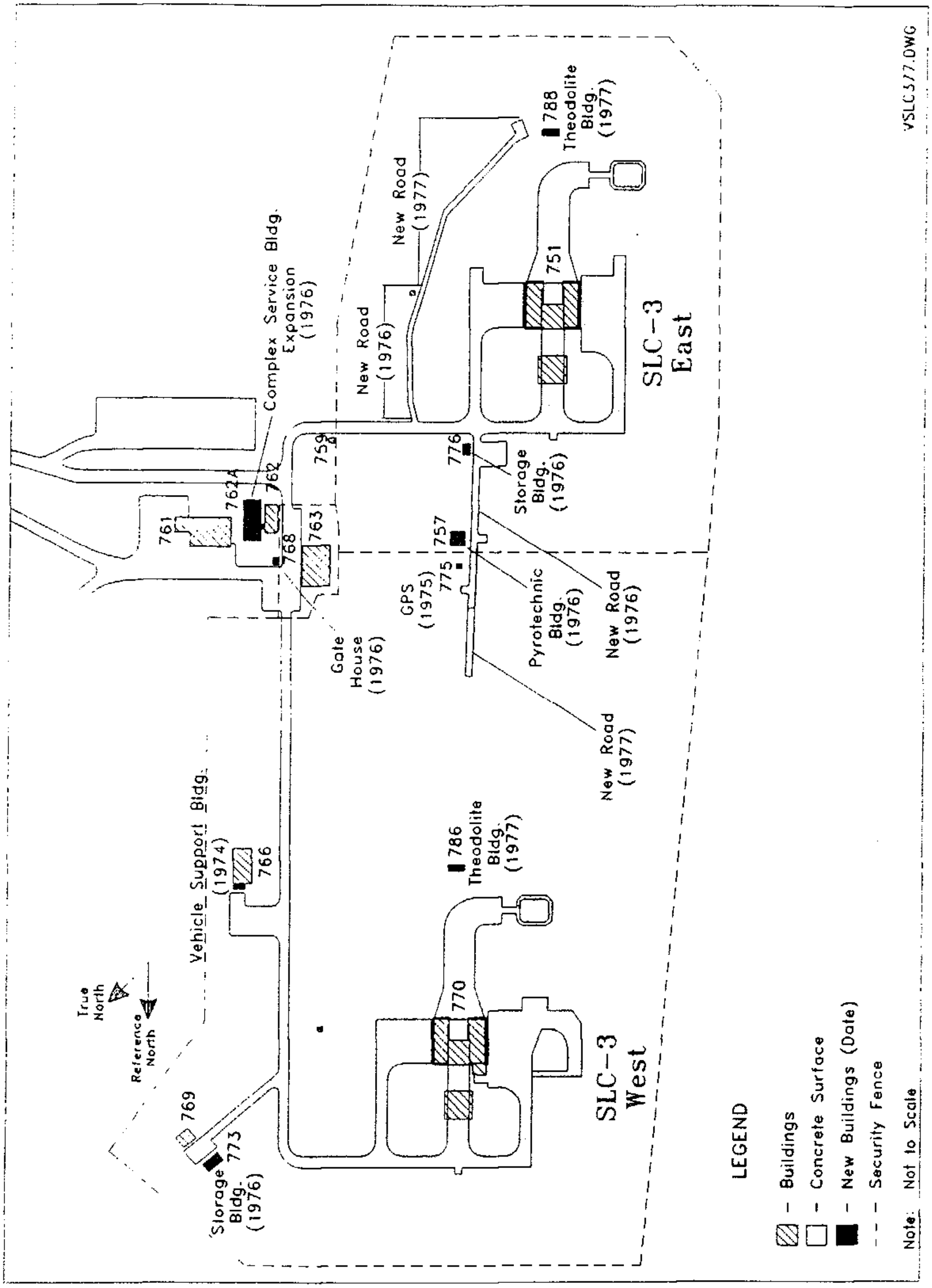


Fig. 5.3. Space Launch Complex 3, 1977 configuration

were replaced with concrete structures in 1980, after the original Building 786 was blown away by the blast force of the first launch subsequent to construction of the sheet-metal shelter. SLC-3 has remained relatively unchanged since 1977 (fig. 5.4).

The Launch Pads

Originally, both launch pads were identical, having been built from common design drawings and specifications. As time progressed, however, each pad supported different delivery vehicles, necessitating modifications that differentiated the launch pads. Between 1975 and 1982, both launch pads supported the Atlas E/F series of delivery vehicles, making the pads almost identical during that period. SLC-3W remains in the Atlas E/F configuration; however, SLC-3E was converted to the Atlas H configuration in 1982. The original design, construction, and functions of the launch pads are described in order of their most prominent features: the mobile service tower (MST), the umbilical mast, and the Launch Services buildings (Buildings 751 and 770). Modifications of the MST and LSB are described for each launch pad.

Mobile Service Tower

The mobile service towers (MST) at each launch pad are the most prominent features of the complex (photos. CA-133-1-2, CA-133-1-B-1 through B-4, CA-133-1-C-1 through C-15). Both MSTs are visible for at least one mile from Arguello Boulevard and are highlighted against the backdrop of the hilly terrain of the south central coast of California. The MSTs are used to erect, assemble, and service the delivery and space vehicles. The MST resembles a 135-foot high letter "A", 50 feet wide at the base and 28 feet wide at the apex (photo. CA-133-1-9). The towers are constructed in an open framework of structural steel "I" beams, "L" channels, and stringers of various configurations (photo. CA-133-1-B-216). Gusset plates seven-sixteenths of an inch thick reinforce and join the various steel members at each structural joint. All structural members are bolted with one-half to three-quarter-inch high-strength steel bolts, depending on the structural strength required at each bolt location. During modifications of the MSTs, several structural members were welded, and additional members were added for increased strength. Folding platforms line the interior of the MST provide access to the delivery and space vehicles (photos, CA-133-1-B-19, B-25, C-6 through C-9; figs. 5.5, 5.6) at several levels. These service platforms are known as "stations" accompanied by a number designation indicating the height of the platform above the launch deck. For reference purposes, the MST is divided into quadrants around reference north, which lies along the centerline of the MST/launch pad, 46.5 degrees from true north. All directions stated in this documentation are relative to reference north.

Originally, the interior core of the MST from Station 70.5 to Station 122 was lined with a combination of corrugated sheet-metal and translucent plastic siding. Sliding environmental doors on the north and south faces of the MST at the same stations provided additional

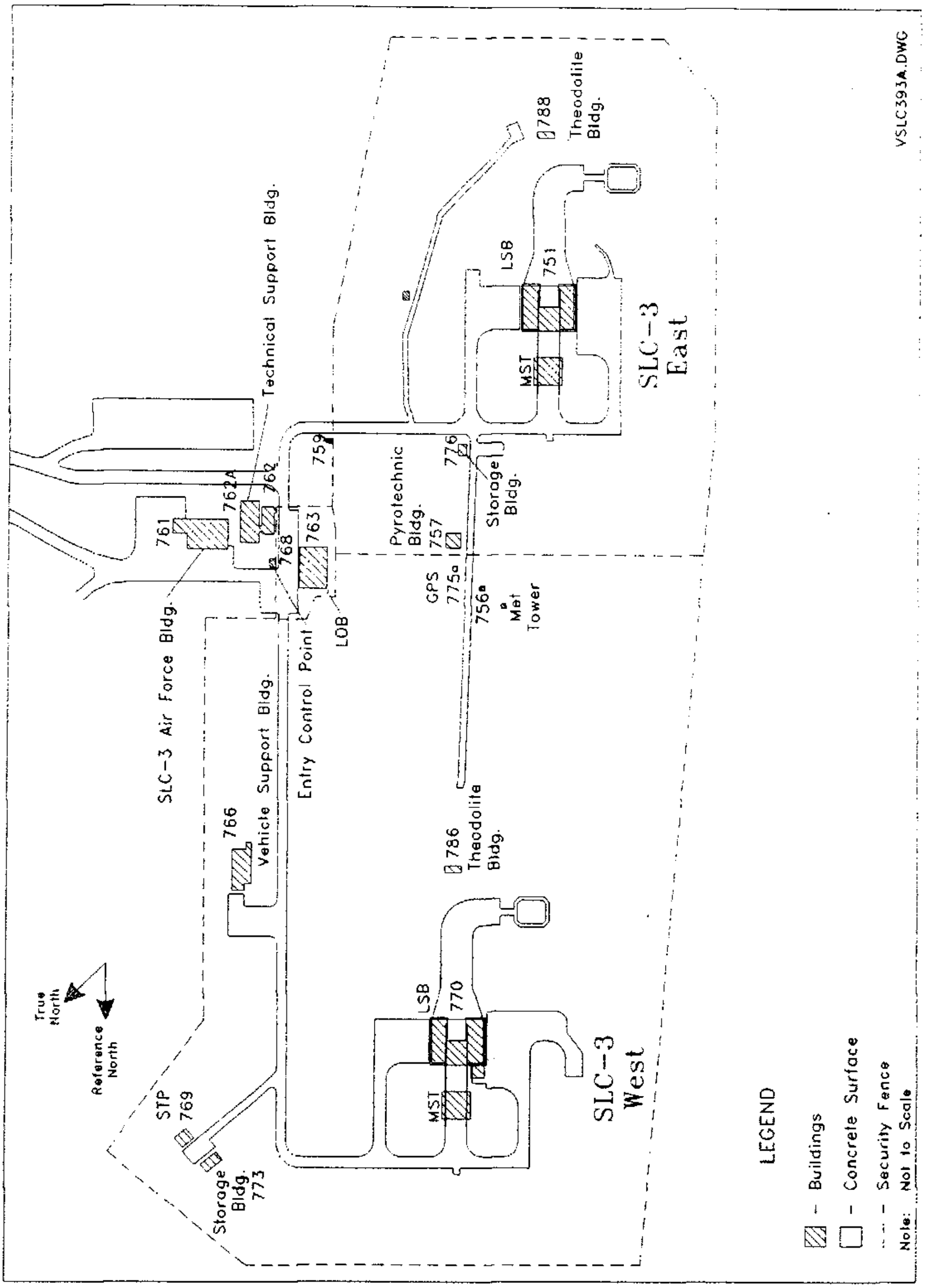


Fig. 5.4. Space Launch Complex 3, 1993 configuration

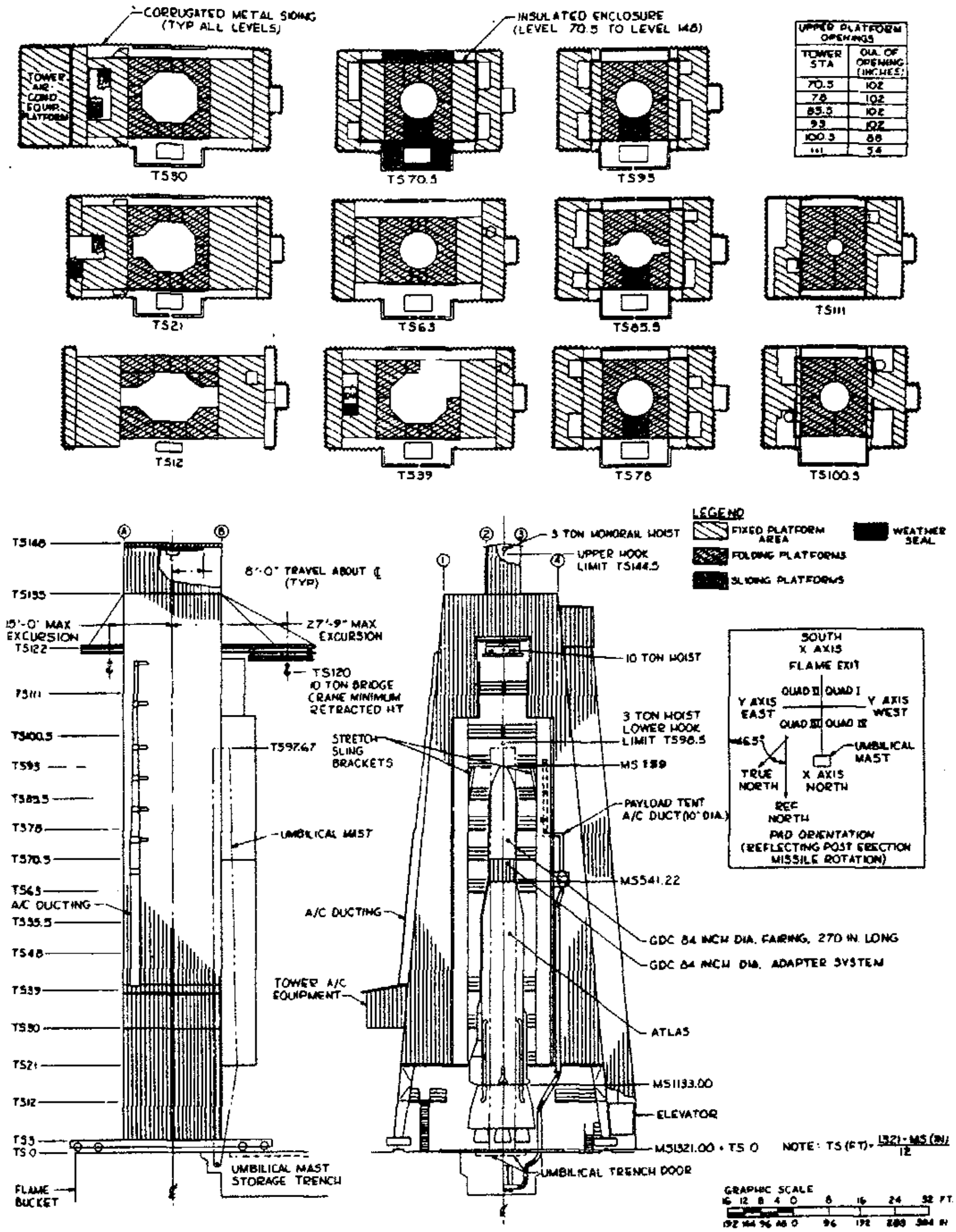
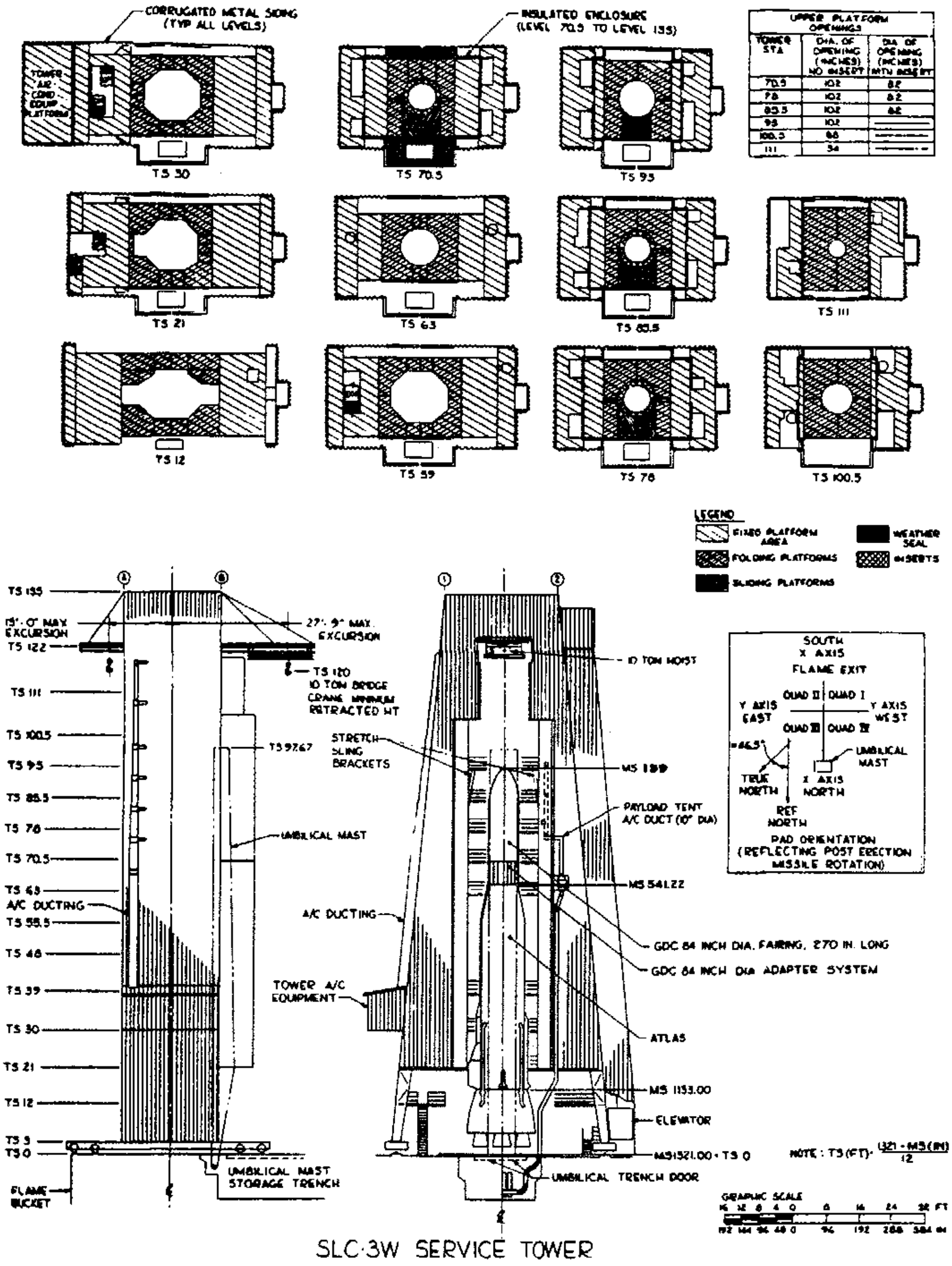


Fig. 5.5. Typical SLC-3E tower platform arrangement
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicle System for Orbital Missions," December 1977)



UPPER PLATFORM OPENINGS		
TOWER STA	DIA. OF OPENING (INCHES) NO INSERT	DIA OF OPENING (INCHES) WITH INSERT
70.5	102	82
78	102	82
85.5	102	82
93	102	—
100.5	86	—
111	54	—

Fig. 5.6. Typical SLC-3W tower platform arrangement
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977)

protection from the elements for personnel and the space vehicle (photos. CA-133-1-11, B-216). These doors were constructed of canvas fabric riding on rigid, round rails. The sliding frames were pulled open or closed by hand-operated winches located at each level (photos. CA-133-1-B-162, B-163). Additional corrugated sheet-metal and translucent plastic siding was installed during 1960 and 1961 between stations 3 and 70.5 and on various areas of the Station 3 work platforms (photos. CA-133-1-B-155, B-163). During the same period, sliding canvas doors similar to those at Station 70.5 were added to stations 21 and 30. Environmental canvas curtains between Station 21 and the launch deck also were added to the north and south faces of both MSTs between 1960 and 1961.

The base of the MST is a trolley, 50 feet long and approximately 6.6 feet wide, constructed of 24-inch "I" beams (photos. CA-133-1-B-16 through B-18, B-165, B-166). The top of the trolley is Station 3. The trolley allows the MST to move on rails from its service position over the flame bucket to its parked position at the north end of the launch pad. Drive assemblies (photos. CA-133-1-B-165, B-166) are located on the north end of the MST on both sides. Each assembly is powered by a 15-horsepower DC motor through a planetary gear-reduction system. Power to the wheel trucks is transmitted by a double-chain drive to the primary, 24-inch wheels, and by a single-chain drive to the secondary 24-inch wheels. Idler (unpowered) wheel-trucks are located on the south faces of both the east and west "legs" of the MST. Side-thrust rollers (photos. CA-133-1-B-165, B-166), one on each side of the wheel truck are provided at the center of each powered and idler wheel truck to prevent derailment and to handle side loads. Hydraulically operated rail clamps (photo. CA-133-1-B-165) are located on each trolley to stabilize the tower and hold it in a fixed position. An operator's cab with controls is located on the northwest side of the trolley. Control circuitry governing tower direction and speed is activated through electromechanical relays. Normally, open limit switches provide feedback to the operator and to the LOB (Bldg. 763) when the tower is over the flame bucket, 90 feet from the flame bucket, and in its parked position at the north end of the launch pad. The trolley also provides a platform for several MST support facilities (photos. CA-133-1-B-16 through B-18, CA-133-1-C-17, C-19). These include the vehicle erection winch, alternating current and direct current control panels, an air compressor with storage tank, and reels for both power and control electrical cable.

The MSTs ride on 171-pound-per-foot rails (photos. CA-133-1-B-42, B-50, B-167, CA-133-1-C-61) from the service position at the south end of each launch pad to the parked position at the north end--a total distance of 226 feet. The rails are 280 feet long. The rails rest on 1.5-foot wide by 9-inch high reinforced concrete curbs set in heavily reinforced concrete footings. The concrete footings are overlaid with the concrete surface of the launch deck. The reinforcing bars are standard steel rebars of various diameters (photo. CA-133-1-B-167). The rails are held down with rail clips bolted to 1-inch "U" bolts set into the concrete footings every 1.5 feet along the rail length. Reinforcing bars tie the rails together in three places at the north end of the deck to prevent horizontal separation between the rails. Spring-loaded bumpers (photos. CA-133-1-B-16, B-50, B-165, B-167) are positioned at each end of the rails to act as shock absorbers for the MST in case of failure of the electronic limiting switches in the trolley. The bumpers were not in place during the initial operational test of the SLC-3W MST, and a powerful gust of wind during the test resulted in a runaway MST. A tool box jammed between the launcher and the MST trolley prevented the MST from running off its rails at the north end. MST tie downs (photos. CA-133-1-B-275, B-167, C-61) made from 1.5-inch forged steel embedded into the concrete surface of the launch deck at a 45-degree angle are located on the north and south ends of the rails to provide additional stability during high winds. Steel cables connect the MST to the tie downs when wind conditions warrant.

Sliding or folding platforms or both are located at stations 21, 30, 39, 63, 70.5, 78, 85.5, 93, and 111 (photos. CA-133-1-B-159, B-216). In the horizontal position, the platforms provide 360-degree access to all areas of the delivery and space vehicles (photos. CA-133-1-C-5 through C-7, C-21). The platforms must be raised during vehicle erection and movement of the MST prior to launch (photos. CA-133-1-C-25, C-13, C-8, C-14). The Station 12 platform is the only platform that rotates from the centerline of the MST (photos.CA-133-1-B-159, B-216). Stations 12 through 63 provide access to the delivery vehicle; stations 63 through 93 provide access to the space vehicle. The platforms at stations 55.5 and 100.5 were not part of the original plans but were added in 1960 (photos. CA-133-1-B-160, B-163; see as built notes). The platforms are multisectioned with small folding or sliding sections around the annular ring (figs. 5.5, 5.6; photos. CA-133-1-B-20, B-27, B-154, B-157, C-36). The main platform is lifted to nearly vertical with electric winches. The electric winches are either single (photos. CA-133-1-B-23, C-38) or double drum (photos. CA-133-1-C-27) depending on whether a winch lifts one or two platform sections. Each winch has a 1,500-pound capacity and connects to the platform through five-sixteenth-inch, stainless steel cable guided to the platform by steel pulleys or shreaves (photos. CA-133-1-B-23, B-160 C-27, C-38). The sliding portions of the platforms originally were operated by compressed air actuators (photo. CA-133-1-B-173). Sliding platforms are located on stations 70.5, 78, 85.5, and 93 to allow clearance and access for the umbilical lines connecting between the umbilical mast and the space vehicle (photos. CA-133-1-B-163).

Elevator shafts extend from Station 3 to Station 122 (photos. CA-133-1-B-163, B-216) on the west sides of the MSTs. The cable-driven elevators are used to carry personnel and equipment to the various levels of the MST. The elevator shafts and elevator machine rooms are covered with corrugated sheet-metal siding. The elevator machine rooms extend approximately 8 feet above Station 122, and house the electric motor and elevator cable drums (photo. CA-133-1-B-168, B-34, B-35). With the platforms in the vertical position, cross-platform access to the east side of the MST is available only at Station 3 and Station 122. Caged ladders or staircases are available along both the east and west sides of the MSTs (photos. CA-133-1-B-17, C-19). The staircases extend from stations 3 through 39 on the east sides (nonelevator side) of the MSTs (photos. CA-133-1-B-18, B-216). Thereafter, access between stations is through caged, steel ladders built into the MST structure (photos. CA-133-1-B-169, B-163, B-216).

A 10-ton bridge crane that rides on trolley wheels is located on Station 12 (photos. CA-133-1-B-31, B-33, C-47). The bridge crane is used to lift adapters and the space vehicle from ground level to the top of the erected delivery vehicle. Originally, the bridge crane was located on Station 122 and had a horizontal reach of 19 feet to the north and 15 feet to the south (photos. CA-133-1-B-163, B-164). During 1961, the crane was relocated to Station 124. The north reach was extended to 27 feet, 9 inches; the south reach remains at 15 feet (photos. CA-133-1-B-155, B-156, B-158). The original bridge crane allowed the hook to extend between ground level and Station 116 (photos. CA-133-1-B-164). After raising the crane to Station 124, the hook extends from ground level to Station 120 (photo. CA-133-1-B-162). The crane hangs under a trolley assembly riding on girder rails (photos. CA-133-1-B-163, B-164), and is powered by a 15-horsepower winch motor and a 1.5-horsepower traction motor, all with appropriate gearboxes and clutch assemblies. Reels for electrical cable are located on top of the trolley frame to prevent cable snagging (photos. CA-133-1-B-164, B-38, C-50).

Erection winches are located on the south sides of the MSTs at Station 3 (photos. CA-133-1-B-163 through B-165). Each winch is powered by a 15-horsepower electric motor coupled through a gear-driven planetary reduction differential. The delivery vehicle arrives at the launch pad horizontally on a trailer (photo. CA-133-1-B-163). At SLC-3W, the launcher is rotated and attached to the delivery vehicle, which is then erected using a screw jack. At SLC-3E steel cables of 1-inch wire rope run from the winches through reeving pulleys at Station 93 (photos. CA-133-1-B-163, B-164) and then down through the central core of the MST to the trailer. The cable is attached to the trailer, and the rocket/trailer combination is raised to the vertical position. Once the rocket is stabilized in the vertical position, the trailer is detached from the rocket and lowered back to the horizontal. Tension is maintained on the erection cable with a three-quarter inch manila rope to control wind-induced drift and sway. One end of the rope is attached to the trailer end of the erection cable, passing through a pulley block assembly attached to a launch pad tie-down point. The other rope end is attached to a 1-horsepower drum winch (CA-133-1-B-163, B-164). The winches are controlled either from the operator's control cab on Station 3 or by remote control station from Station 75. Control circuits for the winches are similar to those for the MST drive motors, and several circuits are shared between the two systems. A balancing circuit synchronizes the winches to ensure equal assent rates and tension on the erection cables.

Electrical power panels (photo. CA-133-1-B-174, B-18) on the east and west sides of Station 3 provide 120-volt power to the MST electrical receptacles and lights (photo. CA-133-1-B-171). General illumination (photos. CA-133-1-B-40, B-171) is provided by 300-watt, type P overhead fixtures; by type J, 200- and 500-watt, side illuminating fixtures in the inner core of the MST; and by 200-watt, type D, wire-caged fixtures near high-vibration areas. Four 1,500-watt exterior floodlights (photo. CA-133-1-B-171) originally scheduled to be installed on Station 93 were actually installed on Station 100.5 (photos. CA-133-1-B-170, CA-133-1-9). Four sets of 100-watt obstruction lights (photos. CA-133-1-B-170, B-171, CA-133-1-9) are located on top of the MST, one at each corner, as a warning for low-flying aircraft. The obstruction lights are activated by photoelectric relays located at the electrical power panels. A 125-volt, direct current horn (photo. CA-133-1-B-171) is located at Station 55 (photo. CA-133-1-B-170) on the north face of the MST to warn of tower movement. Photograph CA-133-1-B-172 shows typical locations of fire alarms, power receptacles, platform limit switches, and conduit routing for stations 70.5 through 122. The platform limit switches not only control power shut-off in the horizontal and vertical positions but also provide power to the in-series platform interlock contacts. All platform interlock contacts must be closed before a "platform clear" indication is achieved in the LOB and at the Station 3 operator's console.

Originally, plumbing was kept to a minimum in the MST, consisting of a single water riser (photo. CA-133-1-B-173) connected at the launch pad by a flexible hose, and compressed air lines supplied by the air compressor located at Station 3 (photo. CA-133-1-B-165). The water riser provides flow to the emergency eye wash fountains on stations 78 and 85.5, the space vehicle fueling areas, and the emergency shower on Station 85.5. A reeled hose is also provided on Station 85.5 to flush spilled chemicals from the space vehicle and station if necessary. The air compressor supplies compressed air (photo. CA-133-1-B-173) to the sliding platform actuators on stations 70.5, 78, 85.5, and 93, and filtered and regulated breathing air for space vehicle stations (70.5 through 100.5). Unregulated and unfiltered air outlets are provided on several other stations for general cleaning and purging of equipment.

Umbilical Mast

The umbilical mast (photos. CA-133-1-12 through 15) is used to service the space vehicle with air conditioning, electric, fuel, and pressure during launch preparation and launch. The umbilical mast is a retractable, welded steel frame structure 98-feet 7-inches long, 6-feet 6-inches wide, and varying in depth from approximately 5 feet at the base to 3 feet at the top (photos. CA-133-1-B-43, C-54). The side of the mast that faces the MST is covered with steel plates to protect the mast and vehicle servicing systems from the launch blast (photo. CA-133-1-B-41). The steel plates have orifices for air conditioning, electrical junctions, and fueling/ pressurization systems. In its fully retracted position, the umbilical mast lies in a trench in the surface of the launch pad (photos. CA-133-1-B-230, B-245, C-51). Hydraulically operated doors cover the trench when the mast is fully retracted or fully erected (photos. CA-133-1-B-41, B-43, B-44, C-51). Steel posts along the side and in the center of the trench provide rests the umbilical mast and the trench covers (photos. CA-133-1-B-45, C-52). Orifices in the mast allow the central posts to pass through the mast (photo. CA-133-1-C-51). The mast may be stopped at any angle from the horizontal; however, the mast is normally in the fully retracted or fully erect positions, except during maintenance. For maintenance, the mast is elevated to 10 degrees from the horizontal and placed on stands (photo. CA-133-1-B-43). In its fully erect position, the face of the mast nearest to the MST is 11 feet from the centerline of the delivery vehicle. For the delivery vehicle to clear the mast during lift off, the umbilical mast is retracted to 8.6

degrees from the vertical within 3 seconds prior to lift off, then allowed to deaccelerate to approximately 12 degrees from the vertical (fig. 5.7). During the retraction, the umbilical cords are automatically demated from the space vehicle.

Space vehicle servicing systems pass through the inner structure of the umbilical mast through tubing and piping of various sizes (photos. CA-133-1-B-221, C-52, C-54; fig. 5.8). Six-inch and 10-inch aluminum air-conditioning ducts provide filtered (5 micron), dehumidified air from the LSB air-conditioning room. An additional 0.3-micron filter on each duct is located approximately parallel to Station 76. All air-conditioning ducts after the 0.3-micron filters are made of stainless steel. Outlet ports (photos. CA-133-1-C-56) are located along the duct at locations specific to a particular space vehicle. Flexible ducts connect the air-conditioning port on the mast to mating ports on the space vehicle (photos. CA-133-1-12 and 13). An atmospheric flow vent, located approximately parallel to Station 70, allows increased control of the conditioned air flow (photo. CA-133-1-C-54). During 1975, the 6-inch duct was replaced with a 10-inch duct within the mast only. A 6-inch to 10-inch adaptor mates the ductwork between the LSB and the mast. Stainless steel tubing varying from three-eighths of an inch to 3 inches in diameter provided red fuming nitric acid (fuel), hydrazine (oxidizer), helium, and nitrogen to fuel, purge, and pressurize Agena space vehicles (photo. CA-133-1-B-221). The tubing is secured to the mast frame through welded brackets and clamps at various points along the height of the mast (photos. CA-133-1-B-221, C-52 through C-54). Flexible hose connects the mast tubing and air-conditioning ducts to the respective tubing and ducts from the LSB (fig. 5.8; photos. CA-133-1-B-222, B-223, B-47, C-53). Electrical conduits pass through a metal duct to the umbilical junction box located parallel to Station 78 (photos. CA-133-1-B-221, C-55; figs. 5.7, 5.9). Most of the interior of the junction box is occupied by terminal boards to transfer electrical signals from the mast cabling to the space vehicle umbilical cables. The umbilical cables attach to a mission-specific connector plate located adjacent to the cover plate of the umbilical junction box (fig. 5.9; photo. CA-133-1-C-55). A 16.5-inch by 20-inch mounting plate for electronic equipment that must be located near the space vehicle is available within the umbilical junction box (fig. 5.9).

An umbilical retraction system located on the mast ejects and retracts umbilicals upon command immediately prior to lift off. The system is attached to the mast through a series of brackets located between stations 62 and 74 (fig. 5.7). The umbilical retraction system consists of an adjustable hydraulic/pneumatic cylinder/piston device (fig. 5.10) that uses a pulley arrangement to retract nine steel cables attached to umbilical connectors. The umbilical retraction system can also be used to retract a space vehicle cover. The system can be adjusted to provide a maximum of 1,000-pounds pull force; the speed of operation varies with pressure. Pull points on the mast are adjustable. The umbilical retraction system is designed so that, during normal operation, umbilicals will be demated prior to movement of the mast. Movement of the mast at lift off can also disengage the umbilicals mechanically via static lanyards. Commands for ejection of umbilicals are sent simultaneously with the engine start command.

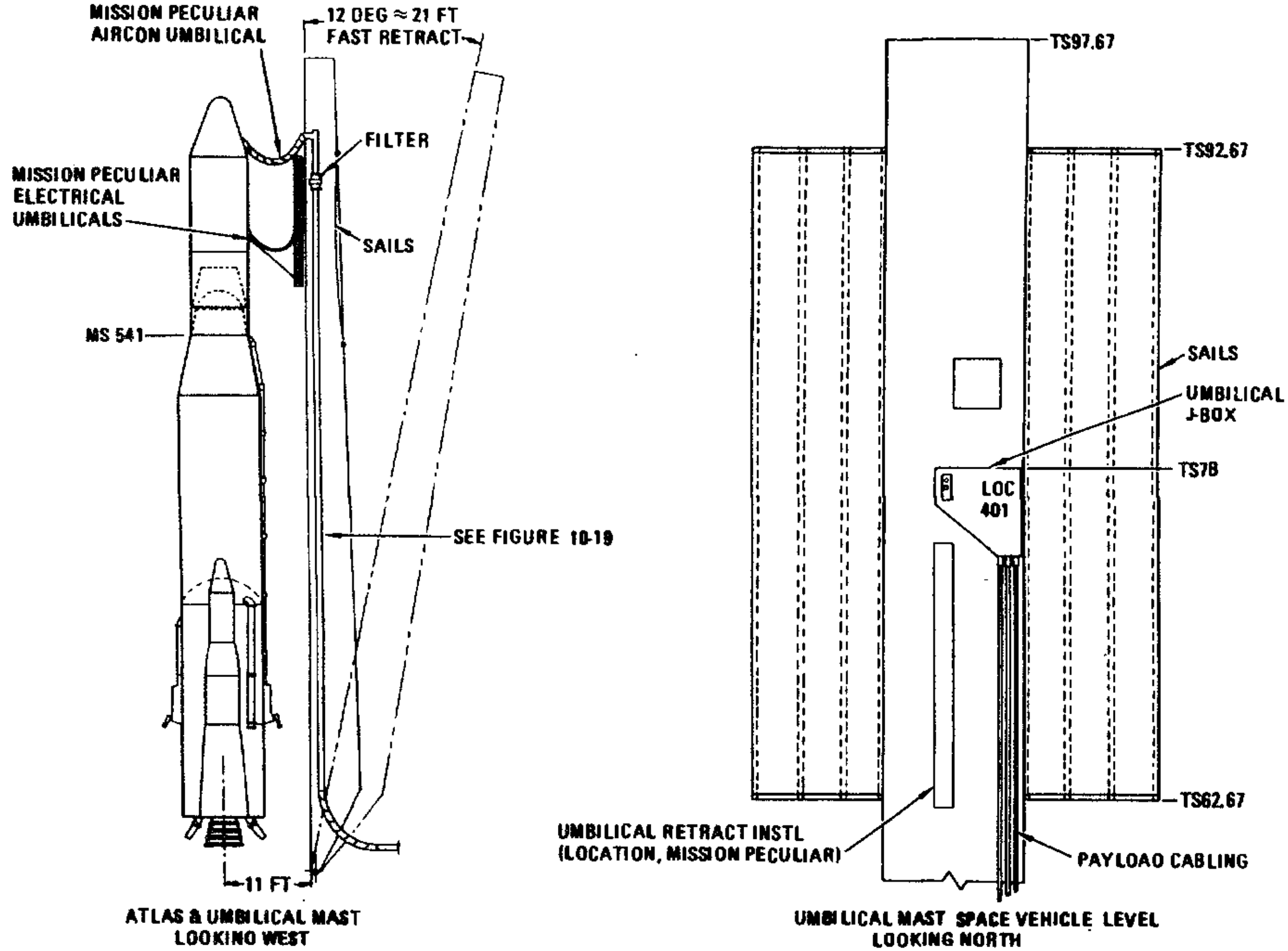
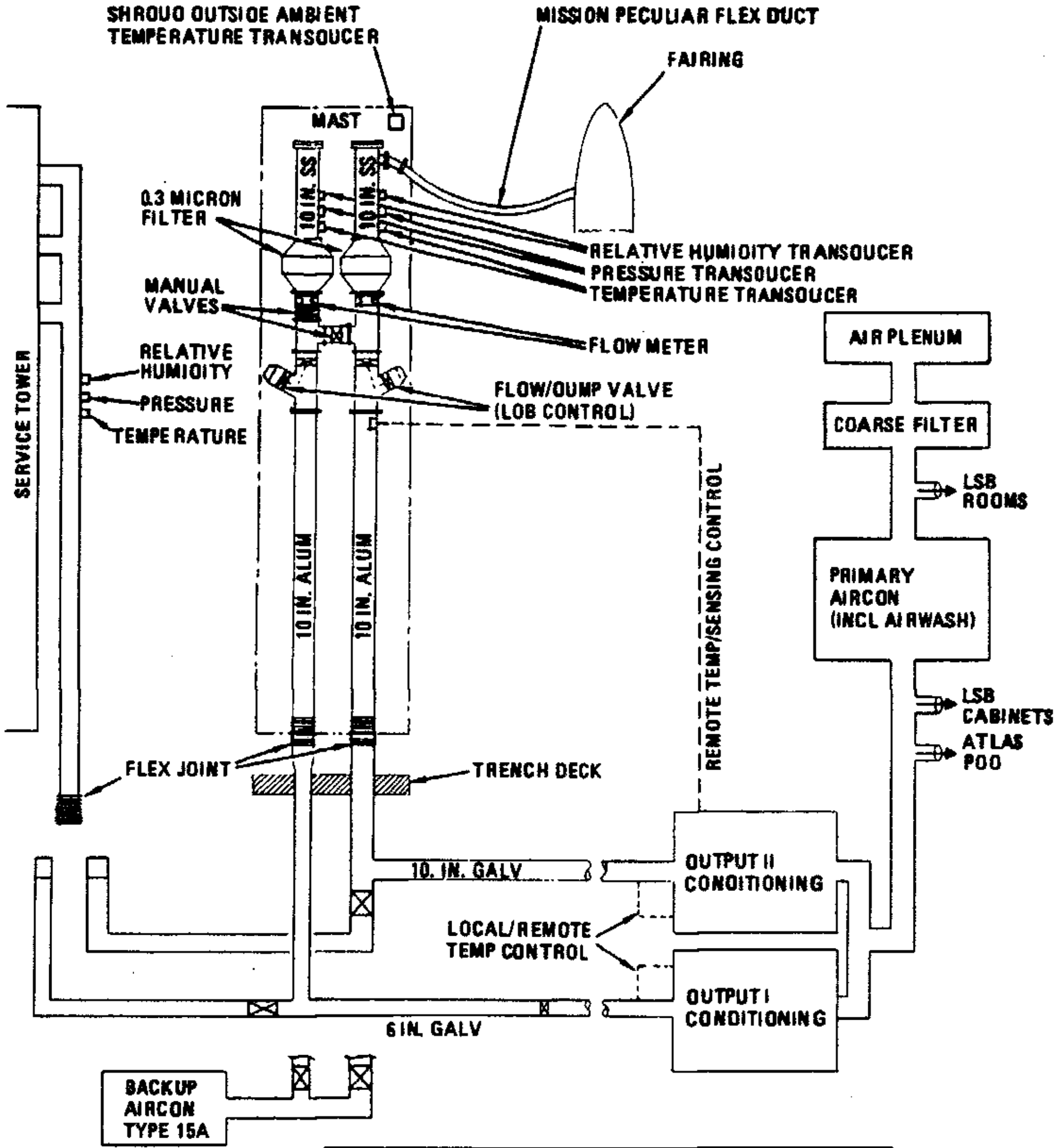


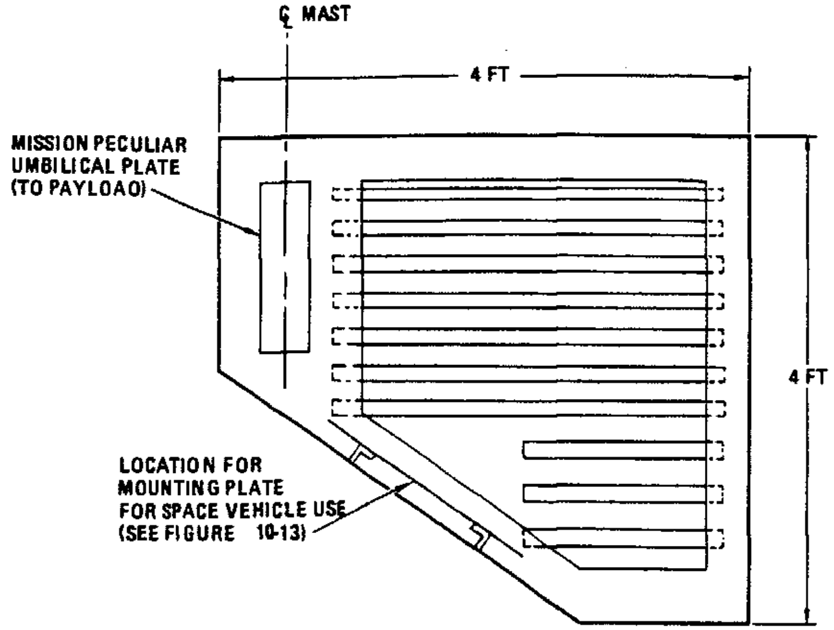
Fig. 5.7. SLC-3 umbilical mast--general arrangement
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977)



	OUTPUT I	OUTPUT II
FLOW	0 - 70 LB/MINUTE	0 - 106 LB/MINUTE
TEMP	50 - 80°F ±5°F*	50 - 80°F ±6°F*
PRESS	0.5 - 1.0 PSI	0.5 - 1.0 PSI
R.H.	50% MAX @ 50°F	50% MAX @ 50°F

*ON SET POINT

Fig. 5.8. SLC-3 Space vehicle air-conditioning system
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977)



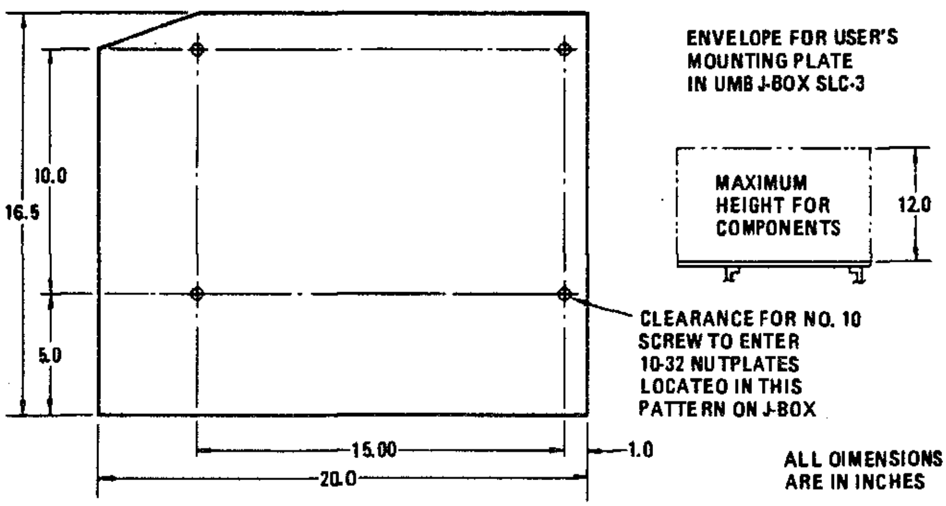


Fig. 5.9. Umbilical junction box on umbilical mast
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977)

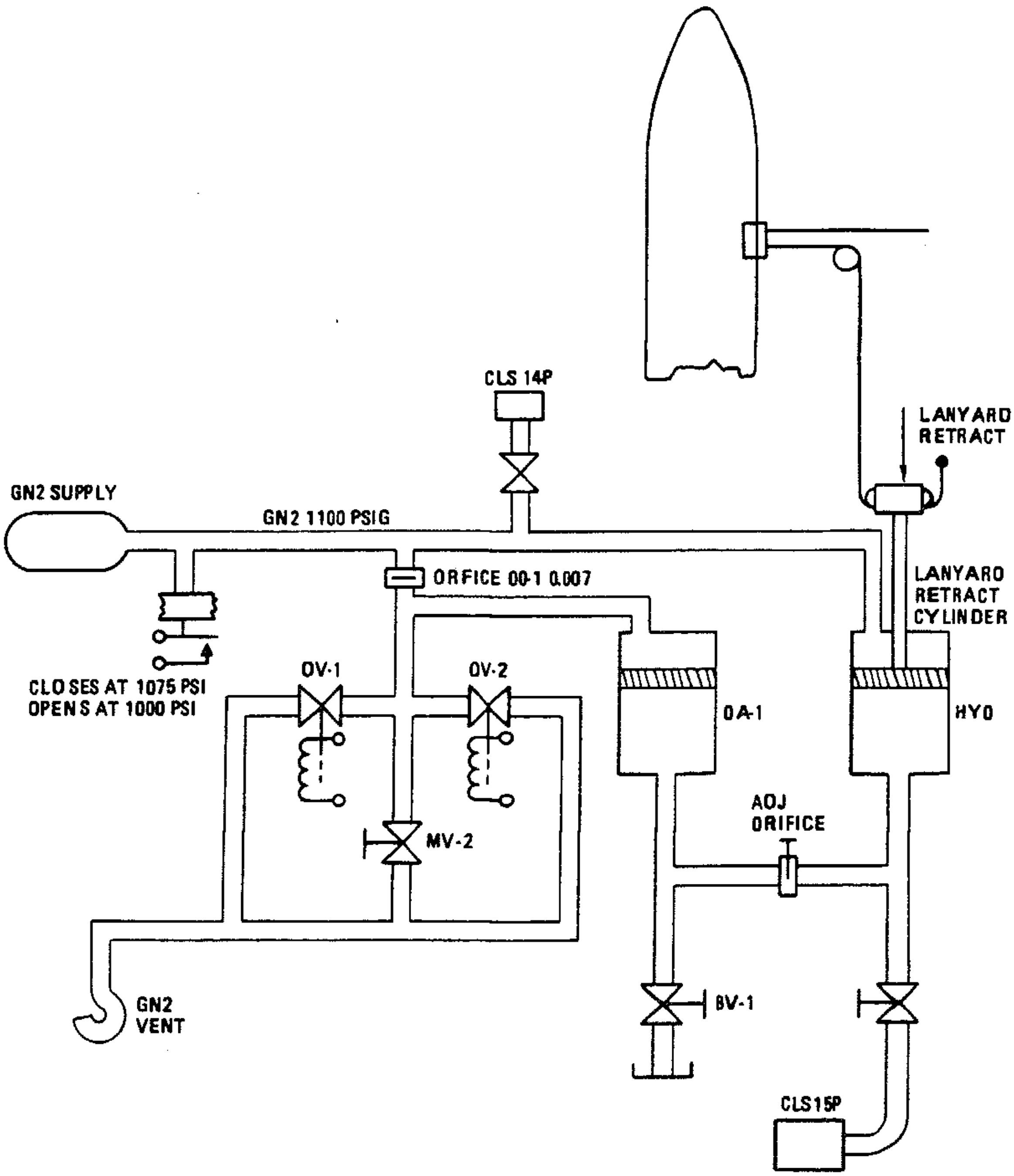


Fig. 5.10. SLC-3 umbilical retract hydraulic/pneumatic system (simplified)
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicles System for Orbital Missions," December 1977)

Specific locations of the retract lanyards on the mast are determined by space vehicle requirements.

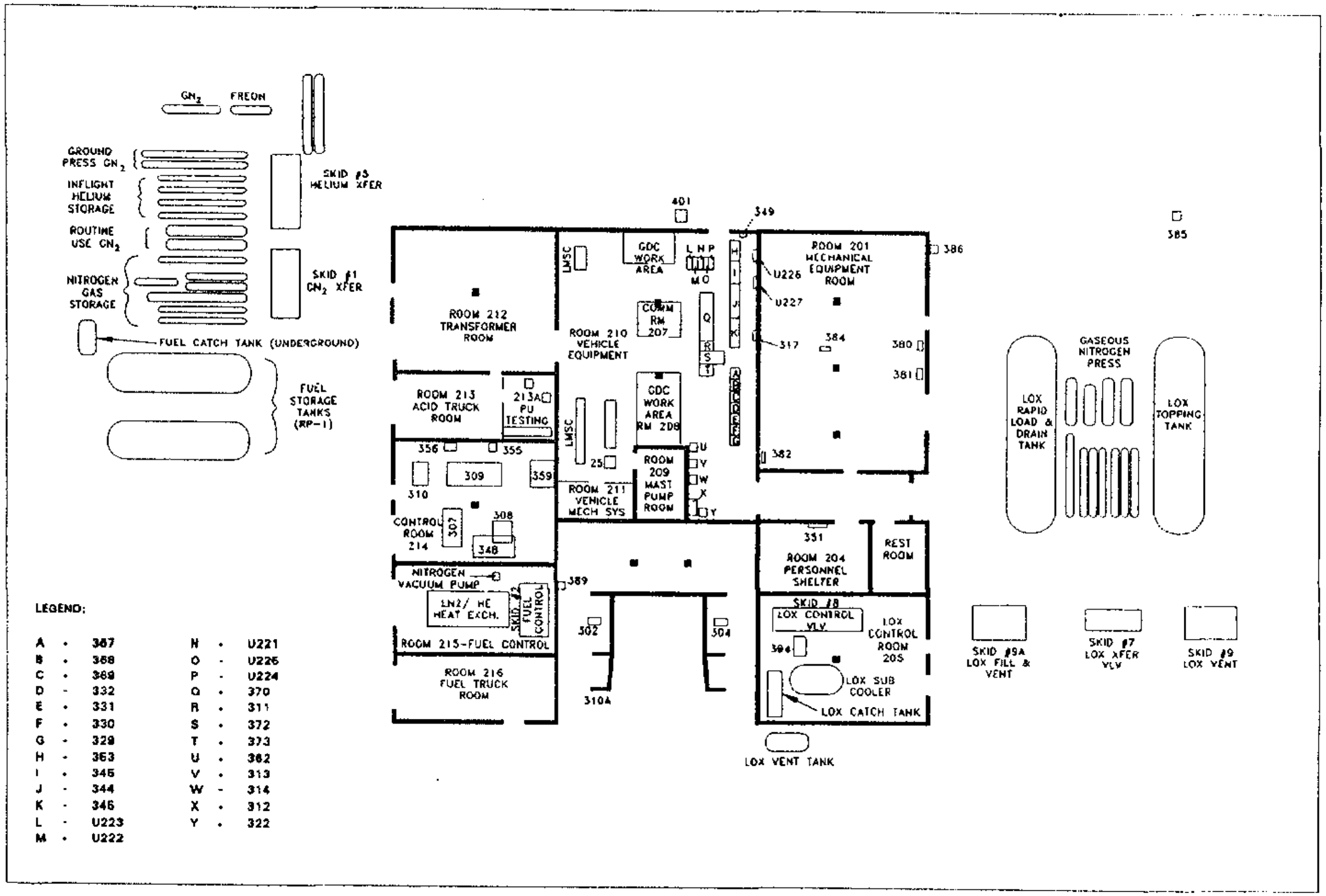
The umbilical mast is raised and lowered hydraulically through two sets of telescoping hydraulic cylinders (fig. 5.10; photos. CA-133-1-B-218, B-219, B-46, C-52, C-53). One set is attached directly to the umbilical mast and extends upon raising the mast; the other set is attached to a scissors linkage arrangement (upper and lower wind strut) that retracts upon raising the mast. This arrangement of hydraulic operators and linkage allows the mast to achieve the necessary close tolerance (one-sixty fourth inch) to plumb and to maintain the plumb position, even under high winds. The Umbilical Mast Pump room is located in the LSB, directly below the mast trench and centered 21 feet, 6 inches from the mast hinge points. The room contains the electrical and hydraulic control panels, hydraulic pumps, accumulators, solenoids, and regulators (photos. CA-133-1-B-123 through B-130, C-107 through C-111, B-218) required to raise, lock, and lower the umbilical mast. Stainless steel, hydraulic tubing passes through the ceiling of the room onto the sides of the trench (photos. CA-133-1-B-46, C-53, B-218). Flexible hydraulic fluid hose connects to each cylinder from the ends of the stainless steel, hydraulic tubing. The umbilical mast can be operated from a remote control panel on the launch deck (photos. CA-133-1-B-48, C-58) or from the main hydraulic control panel in the Umbilical Mast Pump Room (photos. CA-133-1-B-130, C-111). In either case, the main hydraulic control panel must be activated and the electric relay set to either local or remote control (photo. CA-133-1-B-123).

Minor modifications of the umbilical mast have been made to respond to space vehicle requirements. An example of a vehicle-specific modification of umbilical mast at SLC-3W is shown in photograph CA-133-1-B-226. Specific systems and tubing are added as necessary, and other unneeded lines are capped off inside the mast, leaving open orifices in the mast face (photos. CA-133-1-C-56, C-57). Notable exceptions occurred during 1967 and around 1977. In 1967, retractable sails were added as a windbreak for the space vehicle section of the mast. The fairly constant, high winds inherent to the Vandenberg area caused difficulty in setting the inertial guidance system and maintaining system stability prior to lift off. The original sails were pulley-operated systems, 25 feet high and extending approximately 5 feet to each side of the mast (photos. CA-133-1-B-224, B-225). The sail system was extended and retracted through a system of pulleys and cabling at the base of the mast. After 1976, the pulley system was replaced with a hydraulic operating system that allowed the sails to be removed and reattached as needed. In 1976 and 1977, the steel facing plates were replaced at SLC-3W and SLC-3E, respectively (photos. CA-133-1-B-227, B-228). At SLC-3W new facing plates were added and relocated (photo. CA-133-1-B-228). At SLC-3E the top 30 feet of facing plates and orifices were replaced.

Launch Services Buildings (Bldgs. 751 and 770)

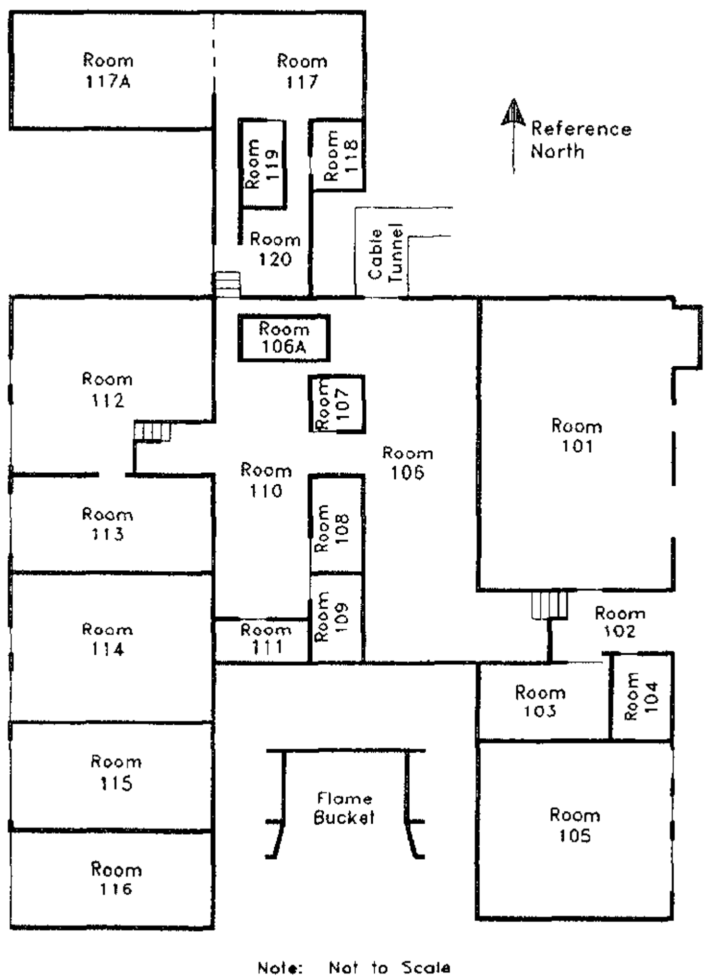
The Launch Services buildings (Bldg. 751 at SLC-3E, Bldg. 770 at SLC-3W) are single-level, 15-foot high, poured concrete structures, 121.5-feet long, and 130-feet wide (photos. CA-133-1-B-244, B-246). They provide all the electrical, mechanical, and pneumatic interfaces to the delivery vehicle and payload and serve as a base from which to launch the vehicle (photos. CA-133-1-B-14, B-69, C-6, and C-9). The roof of the Launch Services Building (LSB) is the launch deck and contains the launcher and MST rails. Built into the LSB is the umbilical mast trench and the flame deflector, or flame bucket, located directly below the launcher. A deluge channel leads from the flame bucket to a retention basin (photos. CA-133-1-C-61, C-64). Reinforced concrete aprons on the east and west sides of the LSB hold the RP-1, nitrogen, helium, and liquid oxygen storage tanks (photos. CA-133-1-B-70, B-88, C-68, and C-78). Each LSB is subdivided into sixteen rooms (photo. CA-133-1-B-247) by poured concrete structural walls. The exterior walls vary from 12 to 15 inches thick; 15 inch walls are most prevalent (photo. CA-133-1-B-69, B-249). Most interior walls are 12-inches thick. All concrete is reinforced with steel reinforcement bars of various sizes. The launch deck, or LSB roof, is constructed of heavily reinforced, poured concrete 12 inches thick. All structural walls rest on 3-foot wide reinforced concrete footings. Reinforced concrete, 2-foot square columns that rest on footings varying between 36-square feet and 72-square feet provide added structural support in the larger rooms (photo. CA-133-1-B-247). Major equipment in the LSBs includes control and monitoring instrumentation for the payload and delivery vehicle; pressurization and checkout units; fueling systems; hydraulic controls for the umbilical mast; air-conditioning equipment for the delivery vehicle, payload, and LSBs; and electrical supply and backup power systems.

The LSBs at the two launch pads were built from the same design, and their floor plans are virtually identical (figs. 5.11 for SLC-3E and 5.12 for SLC-3W). Since the SLC-3W LSB (Bldg. 770) was completed first, its rooms are numbered in the 100s; rooms in the SLC-3E LSB (Bldg. 751) are numbered in the 200s. Although the functions of the rooms in the LSBs are generally the same, some corresponding rooms contain different models of equipment based on differences in delivery vehicles and periods of activity. The critical rooms for supporting launches are the Mechanical Equipment Room (101 and 201), the Liquid Oxygen Control Room (105 and 205), the Landline Instrumentation Room (106 and 206), the Umbilical Mast Pump Room (109 and 209), the Mechanical and Electrical Room (110 and 210), the Transformer Room (112 and 212), the High Pressure Room (114 and 214), and the Fuel Control Room (115 and 215). Several rooms that are currently used only for storage had more significant functions during the Agena program. These include rooms 111 and 211 (formerly the Agena Pressure Room), rooms 116 and 216 (formerly the UDMH Storage Room), and rooms 113 and 213 (formerly the Acid Room). The Propellant Utilization Lab (Room 213A) at SLC-3E was used only during the Atlas H program. Unless otherwise stated, the following descriptions of equipment and functions of the rooms in the LSB apply to both launch pads.



625 - Cable interconnecting box payload
311 - Propulsion Electrical Checkout System (PECOS)
317 - AC power distribution box
359 - Solvent service unit
367 - Airborne Beacon Electronic Test System (ABETS) power supply
368 - Autopilot checkout unit
369 - Autopilot checkout unit
370 - Launch control and monitor unit
371 - Missile ordnance test fixture
372 - Propulsion Electrical Checkout System (PECOS)
373 - Facility distribution console for water control
380 - Heating and ventilating panel
381 - Heating and ventilating panel
382 - System 2 heater controller
384 - System 1 heater controller
385 - Cooling tower
394 - Thrust section heater
U221 - Calibration Control System (CCS)
U222 - Calibration Control System (CCS)
U223 - Calibration Control System (CCS)
U224 - Calibration Control System (CCS)

Fig. 5.11. Current floor plan of SLC-3E LSB (Bldg. 751)



Room Legend

Room 101 – Mechanical Equipment
Room 102 – Hall
Room 103 – Restroom
Room 104 – Office
Room 105 – Liquid Oxygen Control
Room 106 – Mechanical and Electrical
Room 106A – OA
Room 107 – Communications
Room 108 – Work Area
Room 109 – Umbilical Mast Pump
Room 110 – Mechanical and Electrical
Room 111 – Payload Pressure Regulation System
Room 112 – Transformer
Room 113 – Stockroom / Tool Crib
Room 114 – Control
Room 115 – Liquid Nitrogen Control
Room 116 – Storage
Room 117 – Break
Room 117A – Break
Room 118 – Work Area
Room 119 – Work Area
Room 120 – Lunch

VLSBW93.DWG

Fig. 5.12. Current floor plan of SLC-3W LSB (Bldg. 770)

Mechanical Equipment Room (101 and 201)

The air-conditioning systems for the launch pads are located in the Mechanical Equipment rooms, which are rooms 101 and 201 of the respective LSBs. The launch pad's air conditioning system supplies air to the delivery-vehicle stations of the MST (also called the "booster pod"), the payload stations of the MST, and the interior of the LSB. Air from outside enters the building through an air plenum, then passes through a 7-micron, 80-percent efficiency, Roll-Kleen filter; a water shower/air wash; and a 97-percent, 5-micron, high-efficiency particulate (HEPA) filter located at the air-wash discharge. Chilled water is used to cool and dry the air to prevent corrosion in the ducts. After passing through the air wash, the clean, dry air is distributed to the booster pod, the LSB, and the air systems for electronic cabinets in the LSB. The payload air-handling system consists of additional filters, blowers, cooling coils, heating units, and flow and temperature controls. The system can be monitored and controlled from local (pad) or remote (LOB) instrumentation. During the Atlas/Agena program, the final filtration unit for the payload air-conditioning systems at both pads removed 99.99 percent of all particles larger than 0.3 microns. This unit has since been removed from the SLC-3W Mechanical Equipment Room. The current filter for the payload air at SLC-3W is rated at 10,000 particles/cubic foot, 0.5-micron size.

The payload air system is made up of two subsystems: System 1 and System 2. Both provide conditioned, clean air to the umbilical mast to support the payload. Both systems can be directed to either to the MST or to the umbilical mast. System 1 was originally designed to support the ARMA Co. Inertial Guidance (AIG) equipment and could be directed to the AIG pod on the vehicle. The AIG was never used for launches from SLC-3 because the ground guidance system was more reliable; however, AIG features were included in the design plans for the LSB and the vehicle itself.[1] System 1 has an air-handling capacity of 70-pounds-per-minute; the capacity of System 2 is 125-pounds-per-minute. System 2 supplies air to the main payload. Access to the payload fairing is through the umbilical mast. System 1 can be used as a partial backup for System 2. System 1 also creates a "clean room" environment at Stations 70.5 to 85.5 of the MST, if required. Both System 1 and System 2 have similar controls for flow rate and temperature (photo. CA-133-1-B-109). These controls are manually adjustable from the LSB or the LOB. Flow rate and temperature are monitored in both the LSB and the LOB during standby, checkout, and launch operations.

System 1 and System 2 each have three air outlets in the payload area of umbilical mast (corresponding to MST stations 70.5, 78, and 85.5) to accommodate various payload heights. In addition to the umbilical mast ducts, a separate duct provides air to the MST if the umbilical mast is unavailable for use. This MST duct connects to either System 1 or System 2 outlets at the base of the umbilical mast. The MST also has a separate air-conditioning system that provides air for human comfort to various payload stations.

The floor plan of the SLC- 3E Mechanical Equipment Room, as it was configured in 1975, is shown in figure 5.13. The entrance to Room 201 is on the south wall. The main-system blower and the air wash are located northeast of the entrance, and the chilled-water tank is just north of the main air-wash chamber (photo. CA-133-1-B-104). The blowers and compressors (photo. CA-133-1-B-105) that supply conditioned air to the payload are at the south end of Room 201; these are visible from the entrance. Four shell-and-tube, Freon-22 (monodi-chlorofluoromethane) condensers (photos. CA-133-1-B-111, B-112) for cooling water and the booster-pod exhaust fan are located in the northeast corner. Three identical Freon-22 compressors (photo. CA-133-1-B-110) for cooling refrigerant are in the northwest comer, just west of the chilled-water tank. Overhead refrigerant piping and electrical terminals for System 2 controls (photo. CA-133-1-B-107) regulate the conditioned air to the payload. Motor Control Center 2 (photo. CA-133-1-B-108 and C-89) is located on the east portion of the south wall and contains the electrical controls for the air-handling equipment. Instrumentation for controlling and monitoring the temperature and flow rates for both System 1 and System 2 is located on the east wall of Room 201 and provides for continuous recording of duct pressure, temperature, and relative humidity near the outlets to the payload.

The SLC-3W and SLC-3E Mechanical Equipment rooms contain the same types of air-conditioning equipment; however, the configuration of some of the equipment within the rooms is slightly different. At SLC-3W, air-conditioning for human comfort in the MST is provided only to stations 70.5, 78, 85.5, 93, 100.5, and 111 because the SLC-3W MST does not have a cupola.

A backup air-conditioning system is needed for emergency operations in case the primary unit breaks down. Lockheed 15-ampere, portable units were used for backup air-conditioning at both pads until SLC-3E became inactive. The Lockheed system provided flow of up to 70 pounds per minute over a temperature range of 60 degrees Fahrenheit to 95 degrees Fahrenheit, with relative humidity of less than 40 percent at 60 degrees Fahrenheit. The Lockheed system was operated manually and was not very reliable. A newer portable payload air-conditioning system (PPACS) located in a trailer on the SLC-3W oxidizer apron provides remotely controlled backup air-conditioning at SLC-3W (photo. CA-133-1-C-75). The PPACS was installed in the early 1980s. This emergency backup system is a 14-amp unit that can provide 70-pounds-per-minute flow over a temperature range of 60 to 95 degrees Fahrenheit with a relative humidity of less than 40 percent at 60 degrees Fahrenheit. Flow from the PPACS can be directed to System 1 or System 2, or divided between them. The surplus Lockheed units were sent to other locations on base for storage.

<u>Transformer Room (112 and 212)</u>

The Transformer Room contains high-voltage electrical transformers, substation feeders for the LSB and launch deck, power panels A and B, master shutoffs for primary power, and

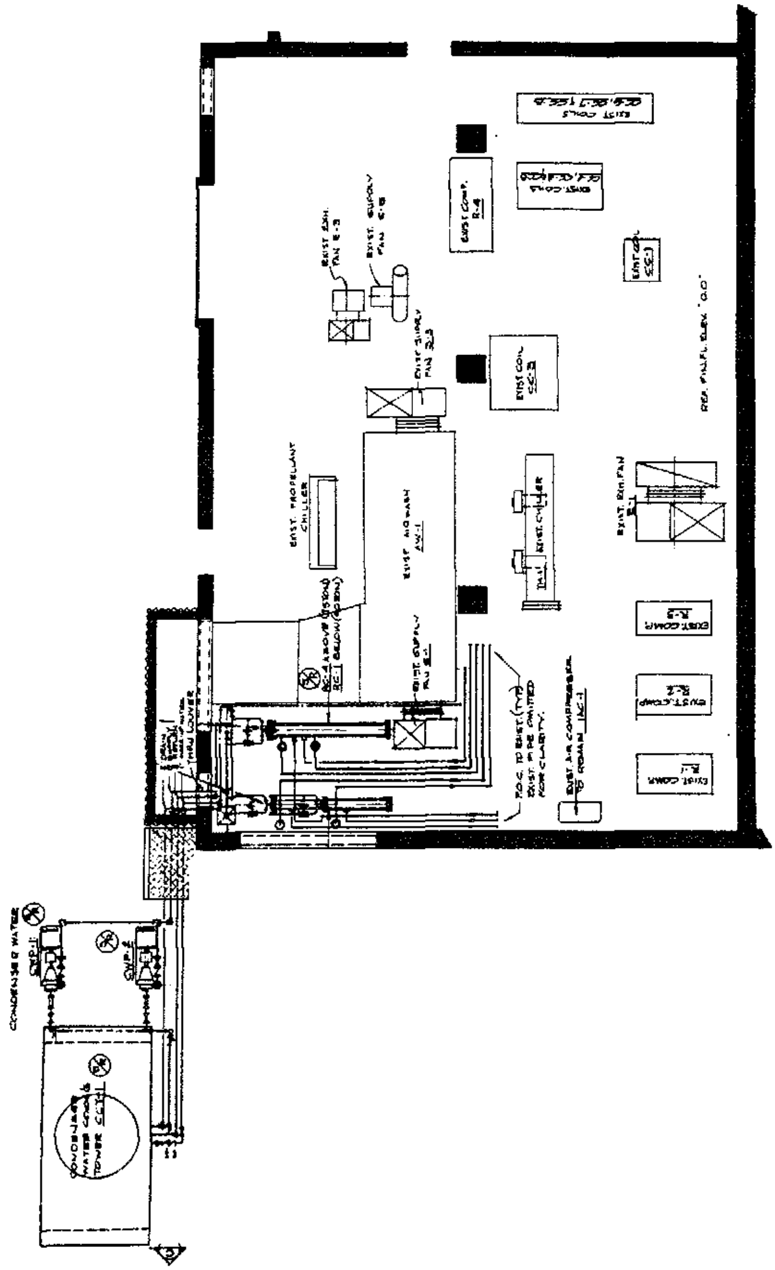


Fig. 5.13. Floor plan of SLC-3E Mechanical Equipment Room, 1975 configuration

Motor Control Center 1. The function and layout of the SLC-3W Transformer Room (112) is identical to that of the SLC-3E Transformer Room (212). Most of the equipment is located in the north half of the room (photos. CA-133-1-B-134 through B-137). The high voltage transformers, main breaker, and substations that feed Motor Control Center 1 and the power panels make up the northernmost row of cabinets (photo. CA-133-1-B-137). Power Panel B (208 volts) and Power Panel A (480 volts) are located on the east wall of the room (photo. CA-133-1-B-137). Another transformer, manufactured by the Jeffries Company (photo. CA-133-1-B-136), is located in the corner between the feeder substations and Power Panel B. This 480/120-volt transformer controls lighting and is tied into Substation 5 (main panel cubicle 5).

Motor Control Center 1 (MCC-1; photo. CA-133-1-B-135) consists of another row of cabinets located south of and parallel to the transformer cabinets and perpendicular to power panels A and B. Motor Control Center 1 controls equipment such as the backup rectifier, a nitrogen vacuum pump, fuel leveling pumps, exhaust fans, and the hydraulic supply unit. All equipment in the Transformer Room, except for the Jeffries transformer, was manufactured by General Electric. Although circuit breakers and wiring have been added and improved during reconfigurations of the pads, none of the power supply or transformer equipment has undergone major modification; all cabinets appear as they did in 1959.

The south side of the Transformer Room is free of electrical cabinets and is used as a loading area (photo. CA-133-1-B-132). The deluge control panel (photo. CA-133-1-C-123) located on the east wall near the interior entrance to the room activates fire suppression systems in the LSB and various areas of the pad.

Landline Instrumentation Room (106 and 206)

The Landline Instrumentation Room (106 and 206) contains the aerospace ground equipment (AGE) for the delivery vehicle and payload, including power supplies, power distribution units, cable distribution units, signal conditioners, and guidance equipment. The landline instrumentation system acquires data from the delivery vehicle and payload for display in the LOB. Equipment in the Landline Instrumentation Room of the LSB is connected to corresponding equipment in the LOB by electrical cables via the cable trays. The functions of equipment in Room 106 at SLC-3W and Room 206 at SLC-3E are the same, but the dates of installation and manufacturers vary.

The power distribution units and cable distribution units make up the two sets of cabinets on the east side of the Landline Instrumentation Room (photo. CA-133-1-B-116). The signal conditioners are on the north side of the room (photo. CA-133-1-B-119), and the logic monitors and controls are on the west side of the room (photo. CA-133-1-B-116). The cables enter the cable distribution unit from overhead cable trays and from below the floor. The vertical cables on the west wall (photo. CA-133-1-B-119) originate from the overhead cable trays and end up below the floor. The floor panels are removable for easy access to the cables underneath. The entrance to the cable tray tunnel (photo. CA-133-1-C-105) is directly behind the signal conditioner cabinets on the north side of the room. Cables go through the tunnel from the LSB (photos. CA-133-1-B-101 through B-103), then via aboveground cable trays to the LOB.

Two 300-ampere rectifiers, originally located in the Landline Instrumentation Room at each pad, provide power by converting alternating current from commercial power supplies to direct current. One rectifier was used for primary power, and the other served as a backup. Currently, only one rectifier (photo. CA-133-1-A-89) remains at SLC-3E; it is now located on the west wall of Room 210. Lead-cadmium batteries and a battery charger are used as a backup for the rectifier power. The battery racks (photo. CA-133-1-B-115) are located in the southwest corner of the Landline Instrumentation Room. One rack serves the delivery vehicle, the other serves the AGE. If 60-cycle power is lost, the AGE batteries provide 28-volt power to the AGE for eight hours. The batteries for the delivery vehicle provide sufficient power to restore the vehicle to safe condition (i.e., drain propellants and helium from vehicle back into storage tanks and perform functions to stabilize the system). The original nickel-cadmium batteries were replaced with newer, longer-lasting lead-cadmium batteries during the Atlas E/F modifications (circa. 1973 at 3W and 1975 at 3E).

Power distribution units at Location 329 through Location 332 (photos. CA-133-1-B-116, C-99) distribute power from the rectifier or batteries to the delivery vehicle. Location 332 provides 400-hertz power for alternating-current reference voltage. This power distribution set includes a standby switch for battery control, a 400-hertz generator, and a rectifier. Prior to 1975, there was an additional 400-hertz power supply in each Landline Instrumentation Room. These additional units were salvaged during conversion to the Atlas E/F configuration because less 400-hertz power was required for the simplified electronics of the Atlas E/F systems. Locations 344 and 345, and locations 352 and 353 are original cable distribution units designed and manufactured by General Dynamics Astronautics in 1959 (photos. CA-133-1-B-116, B-118). An uninterruptable power supply (UPS) was installed in the SLC-3W LSB in 1990 at Location 333 on the south side of the east wall of Room 106 (photo. CA-133-1-C-94). It converts direct-current to 60-cycle alternating current electricity to eliminate power surges.

In the same row of cabinets, next to the power distribution units at Location 332 through Location 329, are the General Electric Airborne Beacon Electronic Test System (ABETS) and the autopilot checkout controls at locations 367, 368, and 369 (photo. CA-133-1-B-117). Location 367 is the power supply for the ABETS; which is connected and calibrated before each launch. General Electric personnel operate and maintain the ABETS. The ABETS is used for ground-testing only. It simulates the ground tracking station during flight simulations but serves no purpose during an actual flight. ABETS was installed for the Atlas E/F program and later was used for the Atlas H program at SLC-3E.[2] The autopilot checkout and controls at Locations 368 and 369 in the SLC-3E LSB were installed during Atlas E/F modifications in the mid-1970s. This equipment came from Cape Canaveral, as did the earlier equipment it replaced. The original equipment for checking out the autopilot system was Automatic Program Checkout Equipment, which was used to check both the airborne systems and autopilot AGE. It was last used to support the 1968 Atlas/Burner II launch. Cabinet 369 is no longer in place at SLC-3W but remains at SLC-3E (photo. CA-133-1-B-117). Cabinet 368 remains in place at SLC-3W, but its interior was replaced in 1990 with new Autopilot Control and Monitoring Equipment (ACME). This autopilot checkout unit performs the same functions as the previous equipment but is a state-of-the-art, computer-controlled unit.

The General Dynamics Calibration Control System (CCS) consists of cabinets U221, U222, U224, and U225 (photo. CA-133-1-B-120, C-102, C-104) located on the north side of the SLC-3E Landline Instrumentation Room (206). These signal conditioners for the telemetry system provide ninety-six channels of data about vehicle performance during prelaunch testing and simulated flight. The CCS equipment dates from the Atlas E/F conversion in the mid-1970s. At SLC-3W, the CCS was replaced with the Landline Instrumentation Signal Conditioning System (LISCS) in 1989. The LISCS is the northernmost set of cabinets on the west side of the SLC-3W Landline Instrumentation Room (106; near the cable tray tunnel entrance). These upgraded cabinets were manufactured by B & F to replace the CCS, which still exists at SLC-3E. Like the CCS, the LISCS provides 96 channels of data.

The test fixture for delivery-vehicle ordnance (photo. CA-133-1-C-100) at Location 371 is located on the south side of the east wall, behind the power distribution cabinets. This equipment was manufactured by Fleming Industries and is known as the Fleming unit. The Fleming unit checks the resistance of the igniter and initiator loops for the booster and sustainer engines. The Fleming unit is a low-current resistance measuring device installed during the Atlas E/F conversions; it was also used during the Atlas H program at SLC-3E. Prior to the Atlas E/F modifications, a simpler, Wheatstone bridge device was used for the same checkout procedures. The Fleming unit will not be used for Atlas II vehicles.

The Communications Room (107 and 207), which contains telephone and intercom controls for the LSB, is located between the Landline Instrumentation Room (106 and 206) and the Mechanical and Electrical Room (110 and 210).

Mechanical and Electrical Room (110 and 210)

The main feature of the Mechanical and Electrical Room is the "Rack Set A" cable-interconnecting box (photo. CA-133-1-B-131). This cable-interconnecting box for payload systems is located just outside the door to the Umbilical Mast Pump Room (109 and 209). During certain missions, equipment for checking out the payload is installed nearby so that cables from the overhead trays can be connected to the equipment. The payload cable-interconnecting box in Room 210 (photo. CA-133-1-B-131) is designated Cabinet 25 and is original equipment from 1959. Prior to the Atlas E/F and H reconfigurations at SLC-3E, the Mechanical and Electrical Room (210) also contained surplus payload AGE for the Lockheed Missile and Space Corporation. The rest of the room is work space and a break area for employees.

The Launch Control System (photos. CA-133-1-B-121, C-102, C-103), located at Location 370 on the northwest side of Mechanical and Electrical Room, is the logic control and monitoring unit for the delivery-vehicle fuel and electronics systems. It is comprises AGE and interconnecting cables for controlling and monitoring eleven delivery-vehicle subsystems: commit, vehicle ground-power, engine, hydraulics, liquid nitrogen/helium, fuel, liquid oxygen, autopilot, pneumatics, facilities, and propellant-level controls. This equipment has local and remote controls for switchover to the LOB before launch. The equipment was originally located at Atlas E and F ICBM sites around the country; it was transferred to Vandenberg when ABRES was modified to launch Atlas E and F delivery vehicles. When SLC-3W was configured for Atlas E/F vehicles in 1973, the launch control equipment from ABRES was installed there. SLC-3E was modified for Atlas E/F configuration in 1976 and received virtually identical surplus equipment from ABRES.

The Propulsion Electrical Checkout System (PECOS) in cabinets U372 and U311 (photos. CA-133-1-B-121, B-122) in the SLC-3E Mechanical and Electrical Room (210) controlled and monitored the Atlas H propulsion system during checkout. PECOS, which was installed in 1981, is located at the south end of the row of cabinets that includes Location 370. Cabinet U373, between the Launch Control System and PECOS, is the Facility Distribution Console for the Water Control System (photos. CA-133-1-B-121, B-122). It has a Convair manufacturer's label near the top of the cabinet, with a Sorensen & Company alternating-current voltage regulator at the bottom.

Umbilical Mast Pump Room (109 and 209)

The Umbilical Mast Pump Room contains the hydraulic controls for the umbilical mast and the doors of the mast trench. The umbilical mast trench is located in the launch deck directly above the Mast Pump Room. Equipment in the room includes the main hydraulic control panel, a hydraulic pump, tubing, and the mast relay box (photo. CA-133-1-B-123). The Umbilical Mast Pump rooms at SLC-3E and SLC-3W are virtually identical, including the equipment and its configuration within the rooms (photos. CA-133-1-C-107 through C-111).

The main hydraulie control panels, made by the Paul-Munroe Company, are dated October 1959 at SLC-3W and August 1959 at SLC-3E. The hydraulics control panel consists of transducers that switch an electrical signal from the manual controls on the launch deck to the hydraulic system and accumulators in the LSB. Most of the transducers were made by Rivett. The electrical relay box (photos. CA-133-1-B-129, B-130) located at the south end of the control panel can be switched to remote for control from the launch deck. The transducers on the right (south) side of the control panel (photo. CA-133-1-B-127) control the actuators for the mast. The transducers on the left (north) side of the panel (photo. CA-133-1-B-125) control the actuators for the trench doors. Several small accumulators for the doors (photo. CA-133-1-B-124) are located on the lower right (south) side of the hydraulics control panel. Another large vertical accumulator for the mast is located behind the control panel along with the tubing for the hydraulic system (photo. CA-133-1-B-128).

A redundant system for mast retraction (photo. CA-133-1-B-126, C-109) was added to the lower left (north) side of the hydraulic control panel for the Atlas E/F program. Immediately after launch, it automatically retracts the mast to 12 degrees from vertical. The redundancy system was originally installed at SLC-3W by Douglas Aircraft Corporation (later McDonnell Douglas) during the Thor program. General Dynamics later installed a similar system at SLC-3E.

Control Room (114 and 214)

The Control Room is a bay on the west side of the LSB near the fuel apron that contains equipment for monitoring pressurized gas used in Atlas AGE. This equipment includes a nitrogen supply panel (NSP), a hydraulic pumping unit (HPU) for the Atlas engines, and a standby pressure control unit for fuel and liquid oxygen, as well as nitrogen and helium piping, and a purge panel.

The NSP and pressure regulator (photo. CA-133-1-B-141) are located in the front of the room on the fuel apron (west) side. The NSP, identified as Location 310, was made by Haskol Engineering of Glen Dale, California, around 1959. The original NSP at SLC-3W was removed from the Control Room (114) by Douglas Aircraft Corporation during the Thor period. The NSP currently in the SLC-3W Control Room was transferred from ABRES when SLC-3W was reconfigured for Atlas E/F vehicles.

An HPU (photo. CA-133-1-B-140) manufactured by Sprague Engineering is located in the center of the room, surrounded by noise reduction panels. Identified as Location 309, the unit has separate controls for supplying hydraulic fluid to the first and second stages of Atlas engines for checkout and countdown. The first stage is the booster engines, and the second stage is the sustainer engine. In addition, the first stage section of the unit supplies hydraulic fluid to the launcher for filling and bleeding the hold-down system. Gaseous nitrogen is supplied to the HPU for internal functions, such as pressurizing reservoirs for the gauge indicators.

The standby pressure-control unit for fuel and liquid oxygen (photo. CA-133-1-B-142) is a backup unit for prelaunch checkout. Identified as Location 307, the unit was made by Feedback Systems, Inc., and has a manufacturer's nameplate dated October 7, 1966.

A purge panel and nitrogen and helium piping to instrumentation throughout the LSB are located on the back (east) wall of the Control Room (photo. CA-133-1-B-144). The nitrogen control unit for supplying the launcher is located on the purge box.

At SLC-3E, a pneumatic supply panel designed by General Dynamics for use in the Vehicle Mechanical Systems Room (211) during the Atlas E/F program was moved to the SLC-3E Control Room (214) to support the Atlas H program. A mobile high-pressure nitrogen cart (photo. CA-133-1-B-143), made by Rocketdyne, is also stored in the Control Room at SLC-3E. It is not generally used in this room; however, it can be moved wherever gaseous nitrogen is needed. This cart dates from October 1960.

At SLC-3W, the thrust-section heater control panel and compressor (photo. CA-133-1-C-134) are located in the northwest corner of the Control Room (114). The thrust-section heater maintains the thrust section of the launch vehicle at the required temperature prior to launch. The control panel for the thrust section heater, Location 394 (photo. CA-133-1-C-135), includes the main shutoff, a chart recorder for air flow rate, and pressure regulators. At SLC-3E, the thrust section heater is on the launch deck, near the launcher.

Fuel Control Room (115 and 215)

The Fuel Control Room is a bay on the west side of the LSB, adjacent to the fuel apron. A 4,600-gallon liquid nitrogen tank located in the front (west) portion of the room takes up most of its space (photo. CA-133-1-C-136). The tank serves as a heat exchanger for cooling helium to be loaded into storage bottles in the booster section of the delivery vehicle (see Chapter 3 for description of Atlas pneumatics system). The helium condenses as it passes through pipes inside the liquid nitrogen tank so that more helium will fit into the storage bottles. Helium piping extends from the nitrogen tank to the launcher (photo. CA-133-1-B-147). Control valves for the heat exchanger and associated piping are located on the south wall (photo. CA-133-1-C-137). An instrument panel (photo. CA-133-1-C-138) monitors the level of liquid nitrogen and pressure in the tank.

At SLC-3E, Skid 2, the RP-1 fuel loader (photo. CA-133-1-B-148), is located at the rear of the Fuel Control Room (215), east of the liquid nitrogen tank. Piping from the RP-1 storage tanks carries the fuel to the loader (photo. CA-133-1-B-146). Additional fuel lines carry the RP-1 from Skid 2 to the launcher (photo. CA-133-1-B-149). At SLC-3W, however, Skid 2 is located on the fuel apron next to the 15,000-gallon RP-1 storage tank (photo. CA-133-1-C-82, C-83).

Liquid Oxygen Control Room (105 and 205)

The Liquid Oxygen Control Room is a bay on the east side of the LSB, adjacent to the oxidizer apron. This room contains Skid 8, the liquid oxygen controller for switching between rapid loading and topping (photo. CA-133-1-B-114). At SLC-3E, rapid loading filled the liquid oxygen compartment in the Atlas H to 90 percent of capacity. The topping system was used to fill the last 10 percent immediately prior to launch. For the Atlas E/F system at SLC-3W, rapid loading fills the liquid oxygen compartment in the delivery vehicle to 95 percent of capacity; then, during countdown, the compartment is topped to 99.25 percent capacity and maintained at that level until commit, when it is filled to 100 percent capacity.[3] Oxygen lines go from Skid 9A (fig. 5.11), which is located on the apron and contains the vent and relief valves and controls for the rapid-load tank, to Skid 8, inside the Liquid Oxygen Control Room.

At SLC-3E, the Liquid Oxygen Control Room contains an 1800-gallon liquid nitrogen tank that serves as a "subcooler" for liquid oxygen during topping. The last 10 percent of the liquid oxygen is cooled via internal piping through the liquid nitrogen tank to ensure that liquid oxygen drawn into the engines when they are started is at a safe temperature. The Atlas D and H engines required subcooling liquid oxygen during topping; the Atlas E/F propulsion system does not suck liquid oxygen when the engines are started. The liquid oxygen subcooler at SLC-3E will be used for Atlas II systems. At SLC-3W, the subcooler used for Atlas D/Agena launches was removed by Douglas Aircraft Corporation during the Thor period.

Acid Room (113 and 213)

The Acid Room was the storage are for inhibited red fuming nitric acid (IRFNA), which was the oxidizer for the Agena space vehicles used during the Atlas D and Thor programs. Unsymmetrical dimethylhydrazine (UDMH) was the fuel for the Agena vehicles. These substances were stored in separate rooms for safety. The Acid Room is now used as a stockroom and tool crib (photo. CA-133-1-B-138, C-129). The original, acid-proof brick floor is still visible in the SLC-3E Acid Room (213), although the brick was covered with vinyl tile in the portion of the room used for the Propellant Utilization Laboratory (Room 213A).

All Atlas delivery vehicles had propellant utilization systems for monitoring the quantities of the two propellants and regulating the rates of consumption of each so that the liquid oxygen and RP-1 were depleted proportionately. The Atlas H, however, was the only model that required a separate propellant utilization laboratory. The Propellant Utilization Laboratory was built over part of the SLC-3E Acid Room (213) in the 1980s. All that remains today is an empty room (photo. CA-133-1-B-139). The equipment on the lab bench in photograph CA-133-1-B-139 is a propellant utilization checkout panel for one of the earlier Atlas configurations. The equipment used in the Atlas H Propellant Utilization Lab was sent to Cape Canaveral. The

Atlas E/F program uses transducers for propellant utilization determinations, as will Atlas II vehicles.

UDMH Room (116 and 216)

The UDMH Room was the storage area for Agena fuel. UDMH was stored in barrels and loaded by weight into a tank before fueling. The room is now used only for general equipment storage (photo. CA-133-1-B-150). Some flame-resistant electrical umbilical cables in the photograph were probably used during the last Atlas H launch and may be reconditioned and reused in future launches from SLC-3E.

Vehicle Mechanical Systems Room (111 and 211)

The Vehicle Mechanical Systems Room, previously known as the Agena Pressure Room, is located at the south end of the Mechanical and Electrical Room (110 and 210), adjacent to the Umbilical Mast Pump Room (109 and 209). Until approximately 1975, Room 211 in the SLC-3E LSB contained two rows of cabinets that supported Agena functions such as pressurization, vehicle power, and propellant loading; however, the room is empty now. The pneumatic supply panel (PSP) that originally occupied this room, was the same type as the PSP still used in Room 111 at SLC-3W (photo. CA-133-1-C-117). The original cabinets and PSP in Room 211 were removed from SLC-3E during the Atlas E/F conversion. General Dynamics designed a new PSP that was used in Room 211 during the Atlas E/F program but was moved to Room 214 for the Atlas H program.

Agena Checkout Facility (117) and Transfer Area Shelter (117A)

Rooms 117 and 117A (photos. CA-133-1-C-139 through C-142) were part of an addition to the SLC-3W LSB made by Lockheed in 1965, during the Thor/Agena program. Prior to 1965, Agena space vehicles were checked out for launch outside the LSB, in a specially erected canvas cabana. Advances in satellite technology demanded a more protected area for preparing the space vehicle to prevent damage of complex payload equipment. Rooms 117 and 117A provided enough room to prepare two Agena space vehicles with payloads simultaneously. Stainless steel pedestals (photo. CA-133-1-C-139) in the floor assured absolutely level conditions during preparation. Four pedestals were used for each Agena. An overhead monorail hoist was used to move the Agena and payload into proper position for checkout. The room was converted to a breakroom in 1968. The monorail hoist was removed, and a tile ceiling and extra lighting were added. A pair of hoists (photo. CA-133-1-C-142) remains in Room 117A near the bay door. These hoists lifted and transferred Agena vehicles into the building. The nitrogen test panel located on the east wall of Room 117A (photo. CA-133-1-C-140, C-141) is a source of nitrogen for test apparatus, such as the mobile cart used to checkout nitrogen systems.

Cable Trays

A cable-tray tunnel extends 25 feet from the SLC-3W Landline Instrumentation Room (photos. CA-133-1-B-256, C-105, C-106), makes a 90-degree bend and continues approximately 180 feet to a 10-foot square cable shaft topped with a corrugated sheet-metal shed. Aboveground cable trays constructed in 1959 connect each LSB to the Launch Operations Building (LOB, Bldg. 763; photos. CA-133-1-A-120, CA-2, CA-3, CA-10). The multiwire, shielded cables within the trays transmit all status and control signals not transmitted by telemetry from the delivery and space vehicles to the LSB and the LOB. A high-frequency wave guide was incorporated into the cable-tray supports during the Agena program. The wave-guide system split off from the cable trays approximately midway between the LOB and SLC-3W LSB. The wave-guide connected directly to the launch pad (photo. CA-133-1-A-119) via a bridge assembly across the deluge channel. The wave-guide system was dismantled in the early 1970s.

The cable trays are mounted on UNISTRUT® brackets set into UNISTRUT® posts (photo. CA-133-1-A-120). The posts, in turn, are set into a 3-foot-square or 4-foot-square by 3-foot deep concrete footings. Each tray is approximately 2 feet wide and 3 inches deep and is constructed of hot-dipped, galvanized metal.

Launch Deck

The roof of the LSB forms the launch deck. The launch deck contains the launcher, the umbilical mast trench, the MST rails, and a variety of support equipment for the MST. Other features associated with the launch deck include the flame bucket, and ground-level aprons flanking the LSB on the east and west sides, which hold fuel and oxidizer storage tanks and controls. Technically, the launch "pad" is the 36-foot 4-inch by 35-foot 3-inch area on the south-central part of the launch deck (photo. CA-133-1-B-245). It consists of a structural-steel framed pad of 1-inch thick steel overlain with approximately 2 inches of concrete, a concrete flame deflector or flame bucket, and a launcher to stabilize the vehicle (photos. CA-133-1-B-58, B-54, B-229; fig. 5.14). The launch pad also contains large diameter ducts and piping for heating the thrust section, loading propellant and oxidizer, and air-conditioning the payload area of the MST (added 1975 and later, photos. CA-133-1-B-54, B-57, through C-59, and C-61).

The launcher is a tubular steel, welded assembly that can pivot from vertical to horizontal to be attached to the Atlas while it rests on the transport trailer (fig. 5.14; photos. CA-133-1-B-54, through B-59, C-59, C-60). The launchers for the D, SLV, and H series of Atlas vehicles were nearly identical. On the Atlas H launcher at SLC-3E, a hydraulically operated hold-down mechanism attached the vehicle to the top pivot points on the launcher. The hold-down mechanism prevented the rocket from moving off the launchers until all of the engines achieved 90 percent thrust (fig. 5.14, 5.15). Once the engines developed sufficient thrust, the hold-down

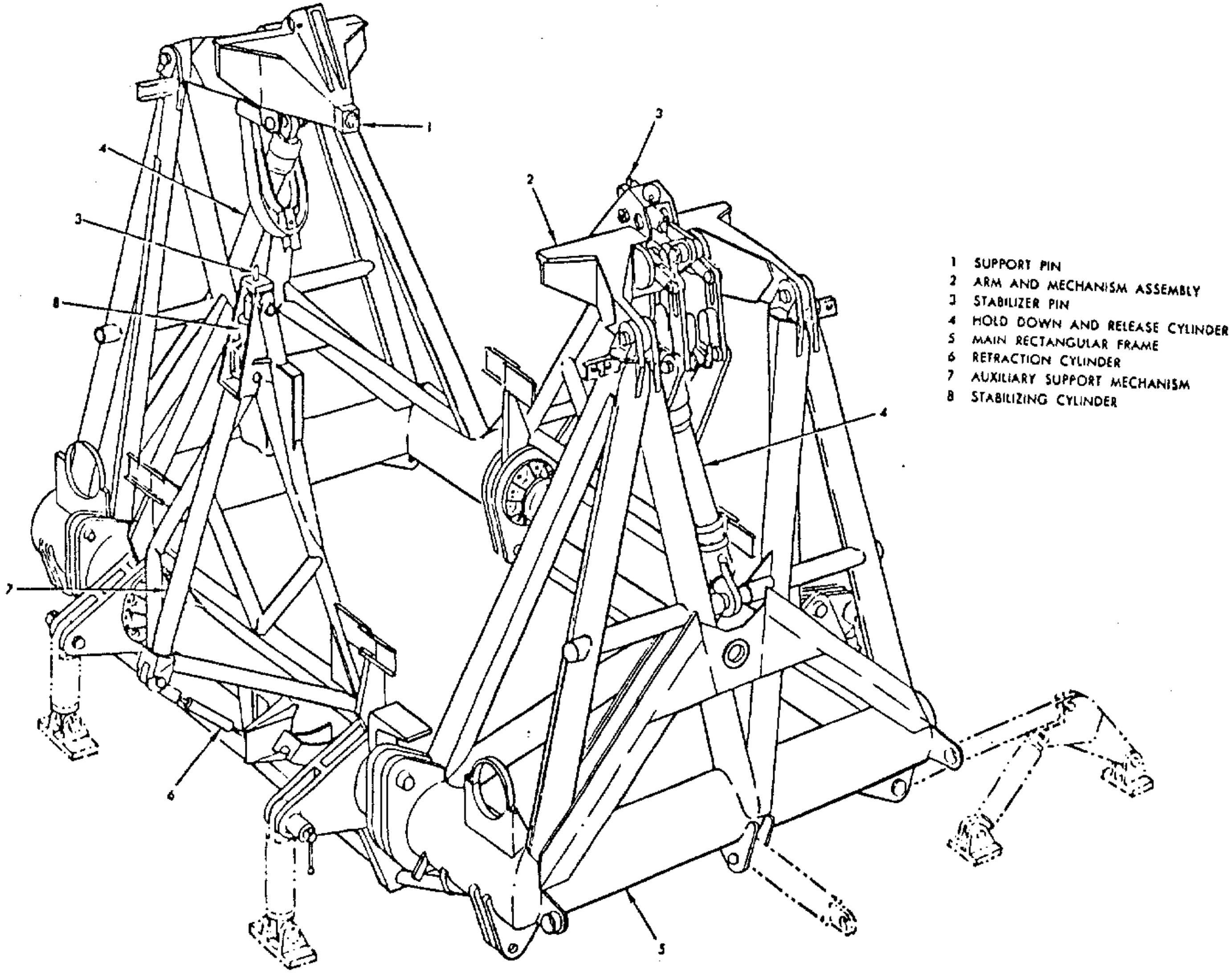
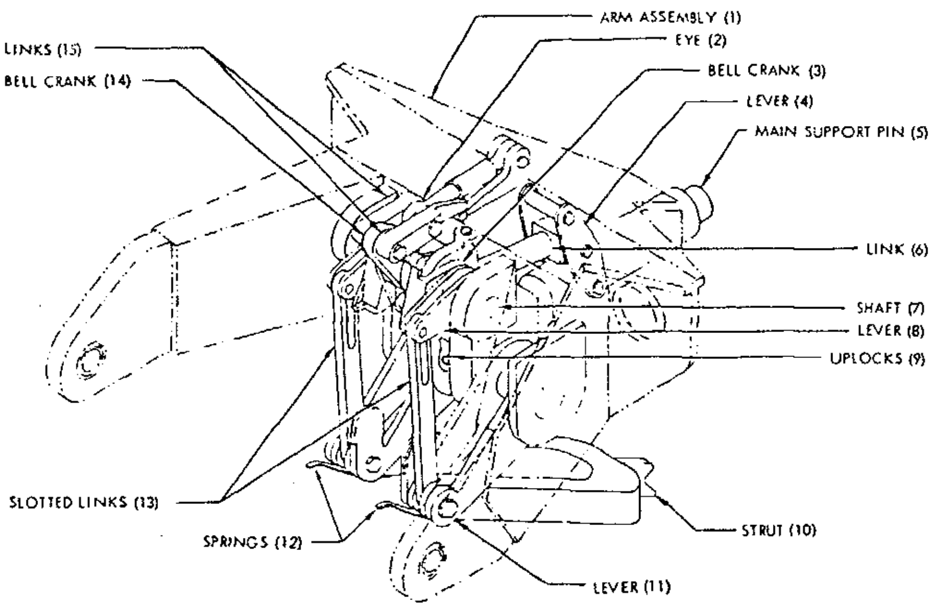
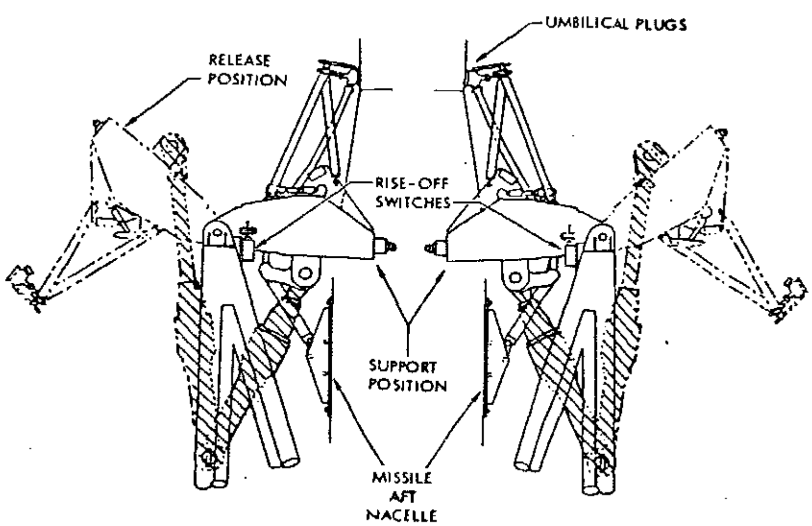


Fig. 5.14. Typical launcher assembly for Atlas D, SLV, and H vehicles
(Source: undated, untitled, document found in Launch Operations Building, December 1992)



ARM AND MECHANISM ASSEMBLY



HOLDDOWN AND RELEASE MECHANISM POSITIONS

Fig. 5.15. Arm/mechanism assembly and holddown/release mechanism positions *(Source: undated, untitled, document found in Launch Operations Building, December 1992)*

heads were retracted, using high pressure nitrogen as the charging medium for a smooth release (figs. 5.15, 5.16, 5.17).

The flame bucket is located directly below the launcher (photos. CA-133-1-B-62, B-63, B-245, B-246, C-63, C-64). The flame bucket deflects the engine exhaust 90 degrees from the launch deck and south into the drainage channel (photo. CA-133-1-B-244). The flame bucket is a heavily reinforced concrete block resting on a 30-inch thick concrete footing (photo. CA-133-1-B-229). Reinforced concrete piles 2-feet wide are sunk 4 feet 6 inches deep along the interior and exterior width of the foundation of the flame bucket to prevent movement due to thrust forces developed during launch. To provide a smooth curved surface, the top 12 inches of concrete were applied pneumatically over reinforcement bars. During launch, water is sprayed from nozzles on the launch deck and interior of the flame bucket (photos. CA-133-1-B-49, B-50, B-243, C-61, C-65) to prevent steel and concrete surfaces from overheating and to suppress noise. Approximately 100,000 gallons of water are used during each launch. The entire ground level of the south face of the LSB is a 4-foot deep, concrete-surfaced collection system known as the deluge channel (photo. CA-133-1-B-62, B-63, B-244, C-63, C-64). The sides of the deluge channel narrow to a 36-foot rectangular flume 50 feet from the LSB. The 4-foot deep by 36-foot wide flume is constructed of poured, reinforced concrete with pneumatically placed concrete above the flume along the slope of the existing hillside. The 36-foot wide flume narrows to a 10-foot wide trapezoidal drainage channel approximately 60 feet from the mouth of the flume (photos. CA-133-1-B-66, C-63, C-66, C-68). The trapezoidal channel empties into a 85-foot by 62-foot, 10-foot deep retention basin. The 150,000-gallon retention basin has no outlets. Deluge water is tested for hazardous compounds, and the water is pumped out and disposed of in an environmentally responsible manner, depending on the results of the analytical tests. Uncontaminated deluge water and rainwater collected in the retention basin is allowed to evaporate.

The umbilical mast trench extends 121.5 feet down the centerline of the launch deck from the launcher (photos. CA-133-1-B-245, B-230, B-41, C-12, C-51). It is 12.5 feet wide and approximately 9.5 feet deep, with a bottom slope of 1 foot in 100 feet towards the south for drainage purposes. The trench is eonstructed of 12-inch thick, reinforced concrete (sides and bottom) and is an integral part of the LSB (photo. CA-133-1-B-239). Seven hydraulically operated doors cover the trench. The doors are constructed of welded structural-steel framing, overlaid with steel grating. The length and width of the doors vary depending on their location (photo. CA-133-1-B-239). Six 8-inch "H" beams set vertically down the centerline of the trench at points where the doors meet support the doors when they are closed. The hydraulic operators for the trench doors are set in recesses in the concrete walls approximately 3-feet below the top of the trench (photos. CA-133-1-C-52, C-53, B-46).

Floodlights are mounted on the launch deck in twelve locations to illuminate the deck and aprons during evening operations (photo. CA-133-1-B-242, B-14, B-42, B-44, C-63). Each light

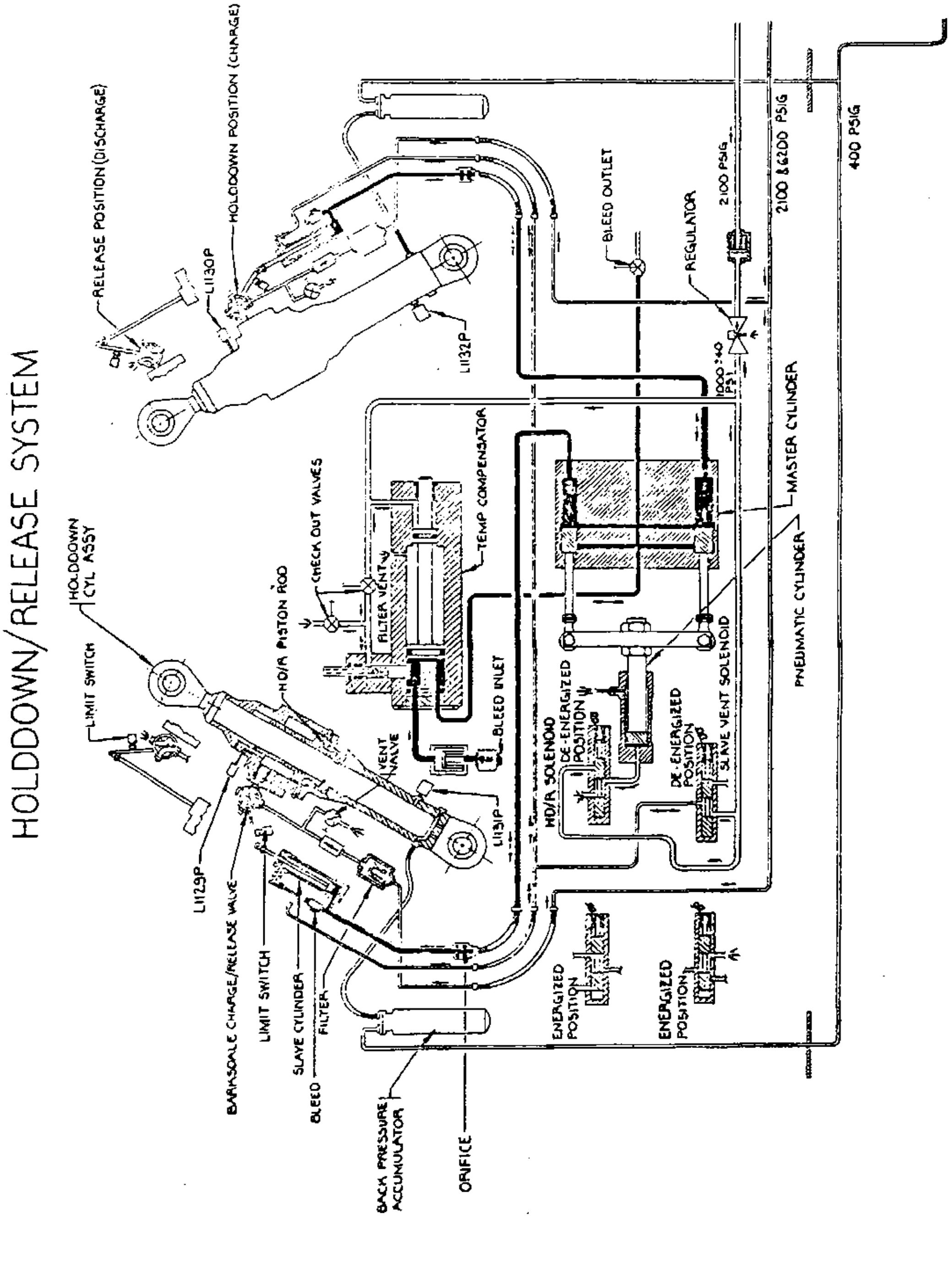


Fig. 5.16. Pneumatic holddown/release system
(Source: undated, untitled, document found in Launch Operations Building, December 1992)

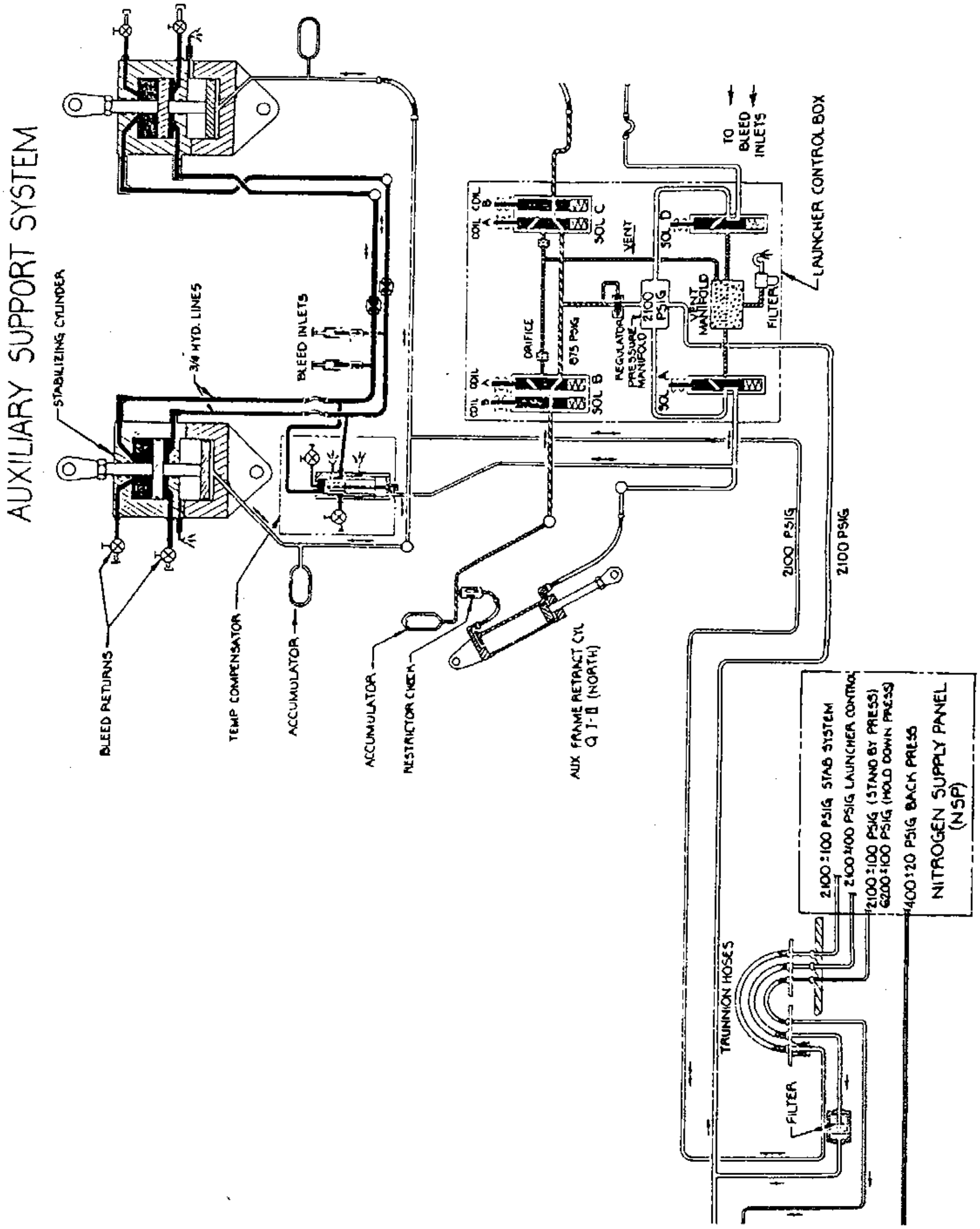


Fig. 5.17. Pneumatic holddown/release system and auxiliary support system
(Source: undated, untitled, document found in Launch Operations Building, December 1992)

standard is 20 or 25 feet high with between four and eight floodlights mounted on top. Several light standards are equipped with Complex Safety warning lights and alarm horns. Electrical power receptacles of various voltages and amperages are mounted on 5-foot stands located beside the MST rails near the parked and service positions to provide power to the MST (photos. CA-133-1-B-51, C-62). All receptacles are explosion-proof. The 100-amperes receptacles include integral circuit breakers. The power receptacles nearest the launcher also contain fire alarm, telephone, and public address pull-boxes. Additional fire alarm pull-boxes are located along the length of the launch deck (photo. CA-133-1-B-242).

Aprons constructed of 7.5-inch thick reinforced concrete extend 85 feet on the east (oxidizer) side and 86 feet on the west (fuel) side of the LSB (photos. CA-133-1-B-69, B-70, B-231, C-69, C-70). Nine-inch thick concrete pads are built into the aprons to hold the various control valve skids. Two-foot deep trenches varying in width from 2.83 feet to 5.83 feet are built into the west fuel apron in various areas to hold the electrical cables and piping (photo. CA-133-1-B-78).

The liquid oxygen storage and transfer system located on the east apron originally consisted of a 28,000-gallon "rapid load" liquid oxygen storage tank, twenty-eight vessels of compressed nitrogen gas for supplying line-blanket and transfer pressure (totaling 1,298-cubic feet in volume at 2,400-pounds-per-square inch), a 1,800-gallon liquid nitrogen tank that serves as a subcooler for liquid oxygen, two 745-gallon liquid oxygen overfill catch tanks, and three control-valve skids (photos. CA-133-1-B-232 through B-234, B-88, B-89, C-68, C-69). The subcooler and catch tanks are located in Room 105 (SLC-3W; photo. CA-133-1-B-14) or Room 205 (SLC-3E) of the respective LSB. The gaseous oxygen transfer pressurization system shown in photographs CA-133-1-B-232 and B-244 was replaced with nitrogen per an 'as built' note dated July 1, 1960.

The control skids vary in length, width, and height; however, they all share common features. All skids are constructed on a structural-steel, pallet-type base so that they can be transported when all piping and electrical cables are disconnected. The skids are framed of structural-steel members with heavy-gauge, sheet-metal sides and tops (photos. CA-133-1-B-90, C-69). One or more steel doors provide access to the various valves and controls. Skid 7 (photos. CA-133-1-B-96 through B-98, B-233, B-234, B-243) contains the control valves, pressure regulators, and gauges to pressurize the oxidizer transfer system with 2,400-pounds-per-square inch of nitrogen and to purge the oxidizer piping with nitrogen after filling is complete. The liquid oxygen storage tank is pressurized with nitrogen through a 6-inch stainless steel pipe from Skid 7. Skid 8, along with the liquid oxygen subcooler, is located in Room 105 (SLC-3W) or Room 205 (SLC-3E; photo. CA-133-1-B-114). Skid 8 contains the control valving, pressure regulators, and gauges for rapid loading through the main, 12-inch stainless steel pipe, and topping through a 2-inch stainless steel pipe (photos. CA-133-1-B-233, B-234). Both the 12-inch and the 2-inch pipes are stubbed on the launch pad when not connected to the delivery vehicle (photo. CA-133-1-B-233). Skid 9 contains the pressure-relief valves and vents for the rapid-load line, as well as the 4-inch stainless steel resupply line for the liquid oxygen storage tank (photos. CA-133-1-B-99, B-100, B-232).

The fuel (west) apron holds the 15,000-gallon RP-1 (kerosene) storage tank; the fuel catch tank (buried); nitrogen purge, pressurization, and fluid transfer vessels varying in pressure from 2,400-pounds-per-square inch to 8,000-pounds-per-square inch; helium vessels used for ground and flight pressurization; and associated piping and control valve skids similar to the oxidizer (east) apron (photos. CA-133-1-B-235, B-236, B-69, C-70, C-71). Like the liquid oxygen system, RP-1 is loaded rapidly by pressurizing the fuel tank with 2,400-pound-per-square inch nitrogen. A 3-inch stainless-steel, nitrogen-pressurization line connects the nitrogen transfer valve skid (Skid 1) directly to the fuel tank (photos. CA-133-1-B-235, B-237, B-79 through B-84, C-80). A 10-inch stainless steel pipe delivers fuel from the pressurized fuel storage tank to the fuel control valve skid (Skid 2) located in Room 215 (Room 115 at SLC-3W; photos. CA-133-1-B-239, B-145 through B-149). Skid 2 contains the control valves and pressure regulators to rapid-load or top (fine load) the fuel compartment of the delivery vehicle (photos. CA-133-1-C-82 through C-84). From Skid 2, the fuel is delivered to the launch pad via a 10-inch stainless steel pipe. The pipe is stubbed at the launch pad until connected to the delivery vehicle. The nitrogen transfer system (photo. CA-133-1-B-238) consists of 424.6-cubic feet of 2,400-pound-per-square inch nitrogen vessels to provide fuel tank pressurization, fuel catch-tank pressurization, fuel tank and fuel line nitrogen blankets, and fluid transfer pressure for the trichloroethylene flushing system associated with the delivery vehicle's engines and the liquid nitrogen/helium heat exchanger located in Room 215 (115-SLC-3W; photo. CA-133-1-C-138). The nitrogen vessels also provide 209-cubic feet of 4,000-pound-per-square inch nitrogen for the hold-down/release and purging systems on the launcher; and 11-cubic feet of 8,000-pound-per-square inch nitrogen used for the umbilical mast rapid retract mechanism and the charge panel for releasing umbilical connections. Most nitrogen lines are regulated through Skid 1 (photo. CA-133-1-B-238). The 8,000-pound-per-square inch lines are regulated at the nitrogen control unit located in Room 214 (114-SL-3W; photo. CA-133-1-C-133) of the LSB. The helium system consists of 519.5-cubic feet of 6,000-pound-per-square inch helium vessels used for ground pressurization, flight pressurization, and routine use (photos. CA-133-1-B-235, B-236, B-240). All helium piping is valved and regulated in the helium control valve skid (Skid 5; photos. CA-133-1-B-85, B-86). Helium for pressurizing the delivery vehicle while it is on the ground and for routine use are delivered directly from Skid 5 to the pressurization control unit located in Room 214 (114, SLC-3W; photo. CA-133-1-B-240).

Associated with each launch pad and located either on the launch deck or a short distance from the deck are television towers, television pedestals, and theodolite shelters. Television cameras are mounted on the pedestals or in the towers just prior to a launch to monitor the launch from the LOB. Five television pedestals (on the deck) and television towers (on the ground) radiate approximately 200 feet from the center of the launch pad in a circular pattern (photos. CA-133-1-B-250, B-52). This orientation provides a 360 degree view of the launch pad and delivery vehicle. The pedestals on the launch deck are constructed of 6-foot high, 4-inch diameter standpipe with a one-half inch mounting plate welded to the top; they are braced vertically with steel members or at a 45 degree angle with 1.5-inch piping (photo. CA-133-1-B-250). The television towers are constructed of open-framed, welded, structural-steel members with a 6-foot by 6-foot platform on top (photos. CA-133-1-B-5, B-6, B-66). A vertical "H" beam with a welded steel plate on top and angled steel bracing serves as the camera mount. A 4-foot high, welded-channel, iron handrail encircles the tower platform for safety purposes. Access to the platform is through a vertical, 2-foot wide, steel ladder mounted to the side of the tower. The tower is set in a large footing 6 feet 9 inches by 6 feet 3 inches by 4 feet 8 inches deep to prevent overturning. The heights of the camera towers vary between 14 feet and 16 feet, depending on location.

Originally, two theodolite shelters were located at each pad: one at the north end of the launch deck on the centerline, the other approximately 320-feet east of the launch pad, centered on the transverse axis, perpendicular to the centerline (photo. CA-133-1-15). Theodolites, which are used to calibrate the inertial guidance systems for the delivery vehicle, were placed over brass markers set in concrete blocks in the floors of the theodolite shelters (photos. CA-133-1-B-9, B-10). The original theodolite shelters were wood framed, corrugated sheet-metal structures 7-feet 4-inches long, 5-feet wide, and 7-feet tall. A 1.5-foot square by 2-foot deep concrete block with a brass marker was set into, but separated from, the concrete foundation by expansion joints. The expansion joints prevented the brass marker block from moving during contraction and expansion of the concrete foundation. A 1-foot 3.25-inch square, hinged door with a 6-inch by 8-inch, sliding, plywood panel allowed a variable opening in case of adverse weather conditions or glare. The only remaining original theodolite shelter is located on the east side of SLC-3E (photos. CA-133-1-B-9, B-10).

Two new theodolite shelters, Buildings 786 and 788, were constructed in 1977 to support NOAA satellites (photo. CA-133-1-B-276). The stations were located directly behind the deluge channel at each launch complex. The shelters were structural-steel-framed, sheet-metal buildings, 44 feet long and 11 feet wide set on concrete foundations (photo. CA-133-1-B-277). Removable panels 2 feet high by 5 feet long were located along a 30-foot length on the side of the building facing the launch pad for sighting purposes. Two concrete piers, one for the theodolite and one for a prism, were sunk below the foundation at least 32 inches deep and isolated from the foundation by expansion joints (photo. CA-133-1-B-277). Due to its proximity to the launch pad flame bucket, the sheet-metal theodolite shelter at SLC-3W was literally blown away by the blast forces from the first launch conducted after the shelter was completed (1980). Both theodolite shelters were replaced in 1980, using 12 inches of reinforced concrete (photos. CA-133-1-B-278, B-279, B-67, C-66, C-67).

SLC-3E Modifications

Atlas SLV Series

Between 1965 and 1966, the SLC-3E MST was modified to accommodate the Atlas SLV delivery vehicle. The most visible differentiation between the SLC-3E MST and SLC-3W MST, the 13-foot high cupola, was added during this modification (photos. CA-133-1-B-174, CA-2, B-1 through B-4). The additional height allowed removal and storage of the fairing (payload flight shroud) and payload service covers during payload servicing and checkout. To add the cupola, the original roof of the MST was removed, and new cross beams were added (photos. CA-133-1-B-174, B-175). The cupola is of similar construction to the rest of the MST, namely a structural-steel frame covered with corrugated sheet-metal. Fixed platforms were added to store the service cover and the fairing. A 3-ton electric hoist and rope suspension-rigging were incorporated into the top of the cupola to remove the service covers and fairing and to suspend the fairing during mating to the delivery vehicle.

Hydraulically operated environmental doors were added to the north and south faces of the MST between Station 70.5 and Station 120.83 (photos. CA-133-1-B-174, B-175, B-177, CA-14, B-4, B-23, B-29, C-38, C-43). The north, lower doors are box shaped, protruding approximately 4.5 feet to allow clearance for the erected umbilical mast (photo. CA-133-1-B-178). All environmental doors are constructed of structural steel framing overlaid with corrugated sheet metal. The lower doors are 8 feet wide, and the upper doors are 5 feet 9.5 inches wide. A manually operated hatch to enclose the 10-ton bridge crane was added to the north and south faces of the MST (photo. CA-133-1-B-174). A small, external platform was added below each hydraulic operator to allow servicing (photo. CA-133-1-C-3). New canvas sliding doors were also added to stations 21 and 30 on the north and south faces. The area between stations 39 and 63, remained open to the elements (photo. CA-133-1-B-174). To maintain temperatures in the payload area within the environmental requirements of the satellite, the interior of the area above Station 70.5 received a coat of insulating polyurethane (photo. CA-133-1-B-174) and an air-conditioning system. The air-conditioning system is located on a 24-foot by 10-foot porch extending from the east face at Station 30 (photos. CA-133-1-B-174, B-179, B-3, B-4). The air-conditioning porch is constructed of bolted, structural-steel members overlaid with 0.25-inch steel decking. The air-conditioning unit is an air-cooled water chiller with a 5,000-cubic-foot-per-minute air handler (photos. CA-133-1-C-21, C-22). A 26-inch diameter duct delivers cooled air to stations above Station 70.5. Electric heating elements (10 or 12-kilowatts) are incorporated into the ducts at each level to maintain even temperatures. Because of the added weight of the air-conditioning equipment, the 24-inch girders at the base of the MST were reinforced with additional welded stiffeners and cover plates along a 31.3-foot central length prior to performing the modifications (photo. CA-133-1-B-182). The main columns between stations 55.5 and 100.5 also were reinforced with welded cover (photo. CA-133-1-B-176). A nitrogen purging system was added to the MST to service the payload at stations 105, 128, and 139 (photo. CA-133-1-B-183). The line is constructed of five-eighths-inch stainless-steel tubing and fitted with stainless-steel check valves, gauges, pressure regulators, and control valves. The purge system connects to the 3,000-pound-per-square inch nitrogen source on the launcher through a flexible stainless-steel hose and quick disconnects (photo. CA-133-1-B-183).

During 1970, the MST was clad with corrugated sheet-metal siding, except for a portion of the north and south faces between stations 39 and 70.5 and a small section between stations 12 and 48 on the south face (photos. CA-133-1-B-184, B-185). The interior metal and plastic siding was removed from Stations 70.5 to the base of the MST. The sliding doors on the east side (quadrants I and IV) of the north and south faces and the air-conditioning porch also were clad with corrugated metal siding. At the same time, all canvas enclosures and curtains were replaced with nylon.

Since the Atlas SLV vehicles were very similar to the Atlas D series, only minimal modifications to the launcher and pneumatic systems were required. The helium and nitrogen cylinders were rearranged to provide a slightly different flow pattern at Skid 5, and additional vent valves were added (photo. CA-133-1-B-251).

Atlas E/F Series

In 1976, SLC-3E was modified for Atlas E/F space delivery vehicles. Required modifications included changing platform configurations and payload fluid processing. Mechanical equipment, that was not necessary for the Atlas E/F was removed from the MST. To improve the environmental conditions within the MST, the MST was completely enclosed with additional corrugated sheet-metal siding and hydraulically operated environmental doors.

Since the Atlas E/F used mechanical screw jacks on the launcher to erect the Atlas vehicle, the erection and tension winches located at Station 3 were removed and placed in storage (photo. CA-133-1-B-187). The rotating platforms and curtain arms located at Station 12 were also removed and placed in storage (photo. CA-133-1-B-187). Other items removed included the folding platforms at Station 55, handrails, sliding fabric doors, various braces, and siding between Station 21 and Station 70.5 (photos. CA-133-1-B-188). Removing the braces and siding provided clearance for the new environmental doors between stations 21 and 70.5. The new environmental doors replaced the sliding fabric enclosures.

The environmental doors between stations 21 and 70.5 are approximately 8 feet wide and 49 feet tall and match the flat (south face) or box configuration (north face) of the doors above Station 70.5 (photos. CA-133-1-B-189 through B-191, B-1 through B-4). The doors are constructed of a structural-steel frame overlaid with corrugated sheet-metal siding. Hydraulic operators for the doors are located at Station 48 (photo. CA-133-1-B-191). The north face between Station 21 and the MST base also received a curtain enclosure similar to the south face.

The platforms at stations 12, 21, 30, 39, and 63 were also reconfigured to accommodate the Atlas E/F. The platform at Station 12 was converted from a swing-out, rotating platform to a fold-up platform (photo. CA-133-1-B-192; SLC-3W drawing shown - SLC-3E identical) with removable aluminum handrails. The folding platform at Station 55.5 was removed and converted to a fixed platform at the original hinge interface (photo. CA-133-1-B-193). The central orifice of the Station 63 platform was reduced to a diameter of 9 feet 4 inches through new platform arrangements (photo. CA-133-1-B-193). Similarly, the folding platforms located at stations 21, 30, and 39 were modified and reconstructed to fit the Atlas E/F with a minimum 2-inch clearance around the periphery of the vehicle (photo. CA-133-1-B-194). Electric winches for operating the platforms at stations 12, 21, 30, 39, and 63 were relocated and additional winches were added to accommodate the new and reconfigured platforms (photos. CA-133-1-B-194, B-195). Other minor changes of platforms included converting the sliding platforms at Station 70.5 and above from the original compressed air actuators to hydraulic actuators (photos. CA-133-1-B-196, B-25, C-33).

A manual pressurization system for the fuel and oxidizer compartment of the delivery vehicle was added at Station 3; pressurization was accomplished with gaseous nitrogen (photos. CA-133-1-B-197, C-17, C-18). An emergency shower, eye wash, and a bottled personnel air supply system were added at stations 78 and 85.5 for safety in case of accidents involving toxic payload fuel or oxidizer (photos. CA-133-1-B-197, B-207). Both the gaseous nitrogen pressurization lines and the water lines terminate at the launcher area. All areas above Station 70.5 received a new interior coat of polyurethane insulation followed by a 0.5-inch thick coat of fire-resistant material and two top coats of white acrylic latex paint (photo. CA-133-1-B-198). The fire resistant coating is an intumescent compound that swells to a thick layer of high-temperature insulation when exposed to heat. The control cabin for moving the MST was covered with a corrugated sheet-metal shelter with plexiglass windows and manual ventilation shutters (photos. CA-133-1-B-199, B-4, C-16).

Minor modifications were made to the MST to accommodate the *Global Positioning System (GPS)* payload. These included adding a 1-ton, monorail chain hoist above Station 3 at quadrant IV (north-west) for loading the payload oxidizer cart from the launch deck to the MST elevator for transport to Station 85.5 and supplying filtered, conditioned air to the payload area at stations 70.5, 78, and 85.5 (photo. CA-133-1-B-200). Ten-inch diameter air-conditioning ducting was flanged off the umbilical mast ducting from the LSB and led up through the launch deck to the MST. A 0.3-micron filter was located at Station 55, ducting below the filter was constructed of aluminum and of stainless steel above the filter (photo. CA-133-1-B-200). To reduce contamination of the payload area and maintain optimum environmental conditions, a sealing system consisting of canvas fabric and foam blocks was added between the delivery vehicle and the service platform at Station 70.5 (photo. CA-133-1-B-201). Payload pressurization systems using helium and gaseous nitrogen (photo. CA-133-1-B-202) were located at Station 78 to pressurize the payload fuel and oxidizer systems during launch checkout (nitrogen) and launch preparation (helium; photo. CA-133-1-C-32). A hydrazine scrubber vent was also added at Station 78 and vented to the atmosphere at Station 135 to eliminate toxic hydrazine fumes during payload fueling operations. A vacuum system was added to all stations except stations 12 and 48 to remove contaminants (photo. CA-133-1-B-203). The vacuum pump was located on Station 3 and driven by a 400-volt, 3-horsepower electric motor. Not directly associated with the *GPS* program, but occurring within that timeframe, the remaining unclad areas below Station 34 received sheet-metal cladding (photo. CA-133-1-B-204) during 1977, and the diagonals and columns between stations 12 and 121 were reinforced with additional welded structural-steel plates and members (photos. CA-133-1-B-205, B-206).

The conversion to the Atlas E/F configuration required major changes in the launch pad and the pneumatic systems associated with the LSB (photo. CA-133-1-B-252). Surplus items, most from ABRES-A, were used extensively for the conversion. The support structure for the launch pad was moved from ABRES-A2 to SLC-3E. To accommodate the ABRES-A2 support structure, the existing SLV/D support structure and the concrete surface were removed, and the top of the flame bucket was reduced approximately 26 inches on the aft side and 13 inches on the forward side (photo. CA-133-1-B-253). The ABRES-A2 structure was added, and the original framing and cross-members were welded or bolted to the new structure (photo. CA-133-1-B-254).

The flame bucket surface was recoated with approximately 4 inches of refractory grout. The Atlas E/F did not require a hold-down release system; therefore, the launcher was also replaced. The Air Force considered several options including designing and manufacturing a new launcher, modifying the existing launcher to the Atlas E launchers located in the VAFB Disaster Pool, and relocating and modifying the ABRES launcher. The latter option was selected, and modifications similar to those previously conducted at SLC-3W were performed (fig. 5.18). The launch pad piping was modified to accommodate the new launcher as well as to simplify maintenance requirements (photo. CA-133-1-B-255). The liquid oxygen system on the east apron required modification because the Atlas E/F used a two-tank liquid oxygen fueling system with warmer engine inlet temperatures (minus 297 degrees Farenheit instead of a minus 320 degrees Farenheit). The Air Force considered reconfiguring the liquid oxygen subcooler in Room 205 into the liquid oxygen topping tank. Since the pneumatic logic would have required extensive modification, the existing 28,000-gallon liquid oxygen tank, Skid 9 (liquid oxygen tank valve), Skid 8 (liquid oxygen control valve), and 984-cubic feet of 2,200-pound-per-square inch nitrogen cylinders were relocated to SLC-3E from ABRES-A1 (photos. CA-133-1-B-256, B-257, B-88 through B-91, B-93 through B-95, B-99, B-100). The original Skid 9 was renumbered to Skid 9A, and the liquid oxygen subcooler in Room 205 was disconnected.

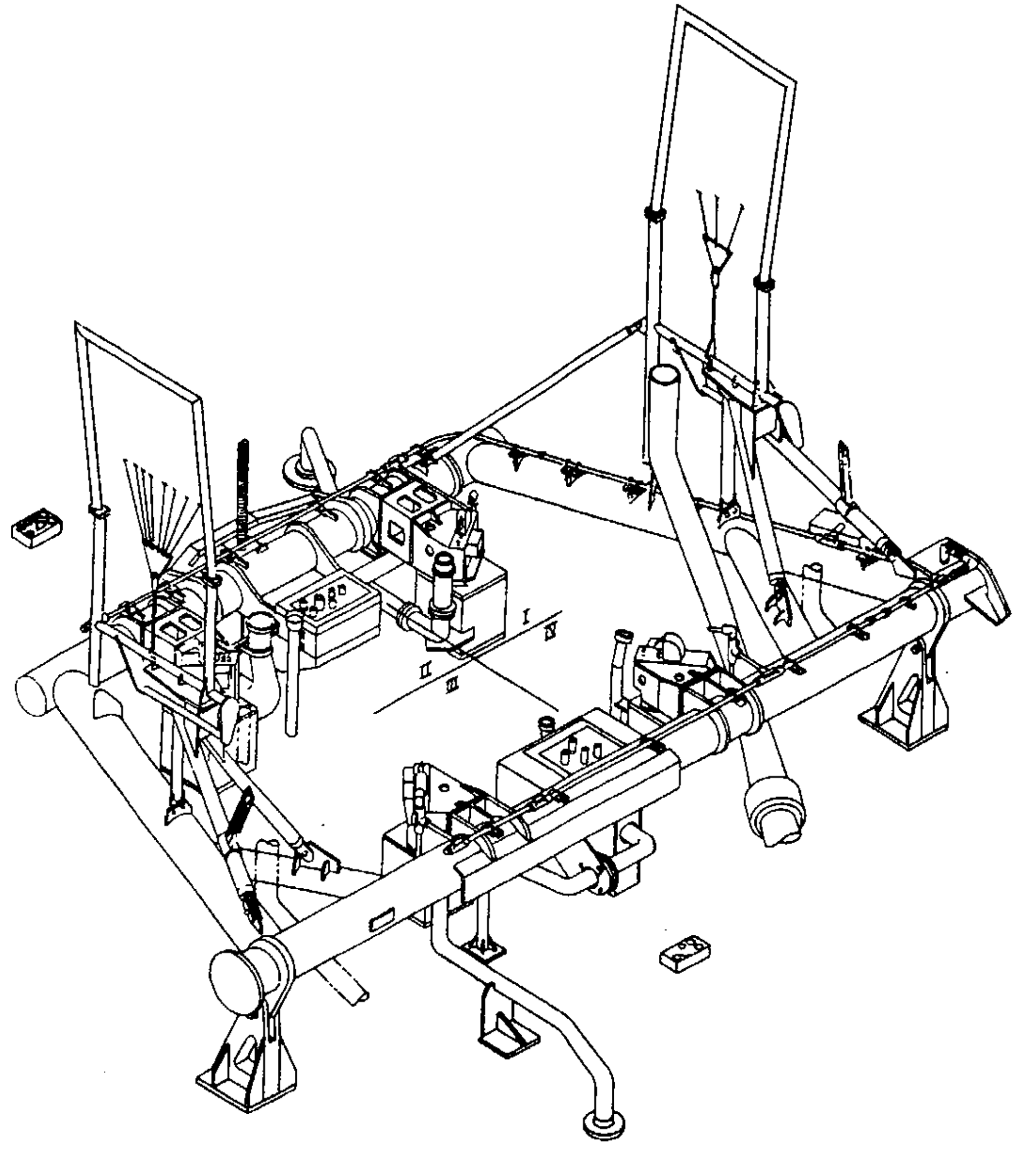


Fig. 5.18. SLC-3E launcher
(Source: General Dynamics, Report No. CASD/LVP 74-075 "Atlas E/F Conversion Study," January 14, 1975)

The pressurization control unit (PCU), dynamic control unit (DCU), and the Ullage Simulation Assembly used to maintain nitrogen pressures in the liquid oxygen and RP-1 tanks during stand-by, propellant tanking, and readiness for launch were also replaced with surplus units from ABRES-A. The Atlas E/F used different procedures during launch preparation, making it technically unfeasible to modify the Atlas SLV units. Since the original hydraulic pumping unit (HPU) that supplied hydraulic fluid to the first and second stage hydraulic systems for checkout and countdown was in poor condition and required modification, it was replaced with one from ABRES-A1. Other modifications included adding a retaining wall/catch basin around the RP-1 feed tanks and a new air-conditioning cooling tower on the east apron (photos. CA-133-1-B-258, B-92).

Between 1976 and 1980, several modifications were performed that were not directly associated with a new series of delivery vehicles. During 1976, a water deluge system was added to the flame bucket to reduce blast damage (photos. CA-133-1-B-259, B-260). A 3-inch pipe equipped with 0.75-inch and 1.25-inch spray nozzles located under the forward launch structure delivered a total of 467-gallons-per-minute of deluge water (CA-133-1-C-65).

Also in 1976, five motion picture camera towers and one television tower were added at various sites within a short distance of the launch deck (photo. CA-133-1-B-273, B-7, B-8, B-11 through B-14). The motion picture towers were fitted with cameras prior to a launch to record lift off characteristics. The towers were similar in construction to the original television towers, except the platforms were enclosed with corrugated sheet-metal to protect the cameras (photo. CA-133-1-B-273). Sliding windows, 4-feet long by 3-feet high, were incorporated into the side facing the launch pad. A basket attached to a one-eighth inch stainless steel cable and a hand-operated winch were used to hoist cameras and film into the tower. The camera towers varied in height from ground level to 36 feet. To prevent overturning, the taller towers were tied down with one-half-inch guy cables (photo. CA-133-1-B-273).

Other additions in 1976 included new sodium floodlights on the launch deck (photo. CA-133-1-B-261) and high pressure lines between the nitrogen source, the pressurization control panels, and the launch pad for pressurizing *GPS* payloads (photo. CA-133-1-B-262). In 1977, a nitrogen supply cabinet for the intertial measurement unit (IMU) was added to support NOAA payloads (photo. CA-133-1-B-263).

In 1979, the west apron more than doubled in size, and a nitrogen and helium pumping system was added (photos. CA-133-1-B-264 through B-266, B-70 through B-76). The original portable carts for recharging helium and liquid nitrogen vessels were in poor condition. Rather than purchasing marginally adequate resupply carts, a large, permanent nitrogen and helium recharging system was installed. A 15,000-gallon liquid nitrogen storage tank, nitrogen vaporizer, and nitrogen pumps were added (photo. CA-133-1-B-264). The liquid nitrogen is converted to gaseous nitrogen in the vaporizer and piped through Skid 1 to recharge the high pressure gaseous nitrogen vessels (photos. CA-133-1-B-265, B-266). The helium is delivered as low pressure on trailer trucks and compressed to 6,000-pounds-per-square inch using the helium compressor installed in 1979. The high-pressure helium vessels are then recharged through Skid 5 (photos. CA-133-1-B-264 through B-266).

Atlas H Series

The Atlas H was very similar to the Atlas SLV; consequently, many of the modifications made to configure the MST for the Atlas E/F vehicles were undone to accommodate the Atlas H. The folding platform at Station 12 was demolished, and the rotating platform that had been removed to storage for the E/F conversion was reinstalled and modified to incorporate hydraulic operators in the rotary actuating mechanisms (photos. CA-133-1-B-208, B-209, B-15). The platform at Station 21 was modified to incorporate manually operated sliding platform sections, and manually operated folding platform sections to enclose the annular opening (photo. CA-133-1-B-210). Stations 70.5 to 93 were equipped with a sealing system similar to the booster seal located at Station 70.5. The seal at Station 85.5, however, provided coverage of the entire top of the payload attachment point (photo. CA-133-1-B-211). Since the Atlas SLV launcher did not include screw jacks to erect the delivery vehicle, the erection and tension winches were taken out of storage and relocated on the Station 3 girder relatively in their original locations (photo. CA-133-1-B-212). Minor modification to the Station 93 platform hinge line and braces occurred to provide clearance for the shreave pulleys and beams. During 1983, the erection winches were relocated to Station 124, near the top of the MST (photos. CA-133-1-B-213 through B-215, B-37). The shreaving beams were eliminated, and the shreave pulleys were relocated inside the MST, resulting in a considerably more efficient and corrosion-resistant erection system (photos. CA-133-1-B-215, B-26). The winch assembly operated from a single motor, using many original winch components including the gearing, wire rope, wire drums, and flanges. A new 15-horsepower motor and gear box were added (photo. CA-133-1-B-213).

The Atlas H was very similar to the Atlas D and SLV delivery vehicles in that it required a hold-down/release system; consequently, the Atlas SLV launcher from Cape Canaveral Complex 13 was relocated to SLC-3E (fig. 5.19). The Complex 13 launcher was installed instead of the SLC-3E SLV launcher that had been stored during the E/F conversion because the Complex 13 launcher had stronger main and auxiliary support frames (photos. CA-133-1-B-54 through B-61). The hold-down heads, trunnions, and erector beam from the SLC-3E SLV launcher were reused. The launch pad support structure was modified slightly, to enlarge the opening by cutting away a portion of the support-structure duct and drilling new attachment points for the Complex 13 launcher (photo. CA-133-1-B-267). The liquid oxygen rapid-load and topping pipeline, and the thrust-section-heater duct were relocated on the launch pad to support the Atlas H configuration (photo. CA-133-1-B-268). The RP-1 fuel and nitrogen capacity was increased by relocating a 15,000-gallon RP-1 storage tank and four nitrogen vessels from ABRES-A (photo. CA-133-1-B-267). The fuel tank was placed next to and connected to the

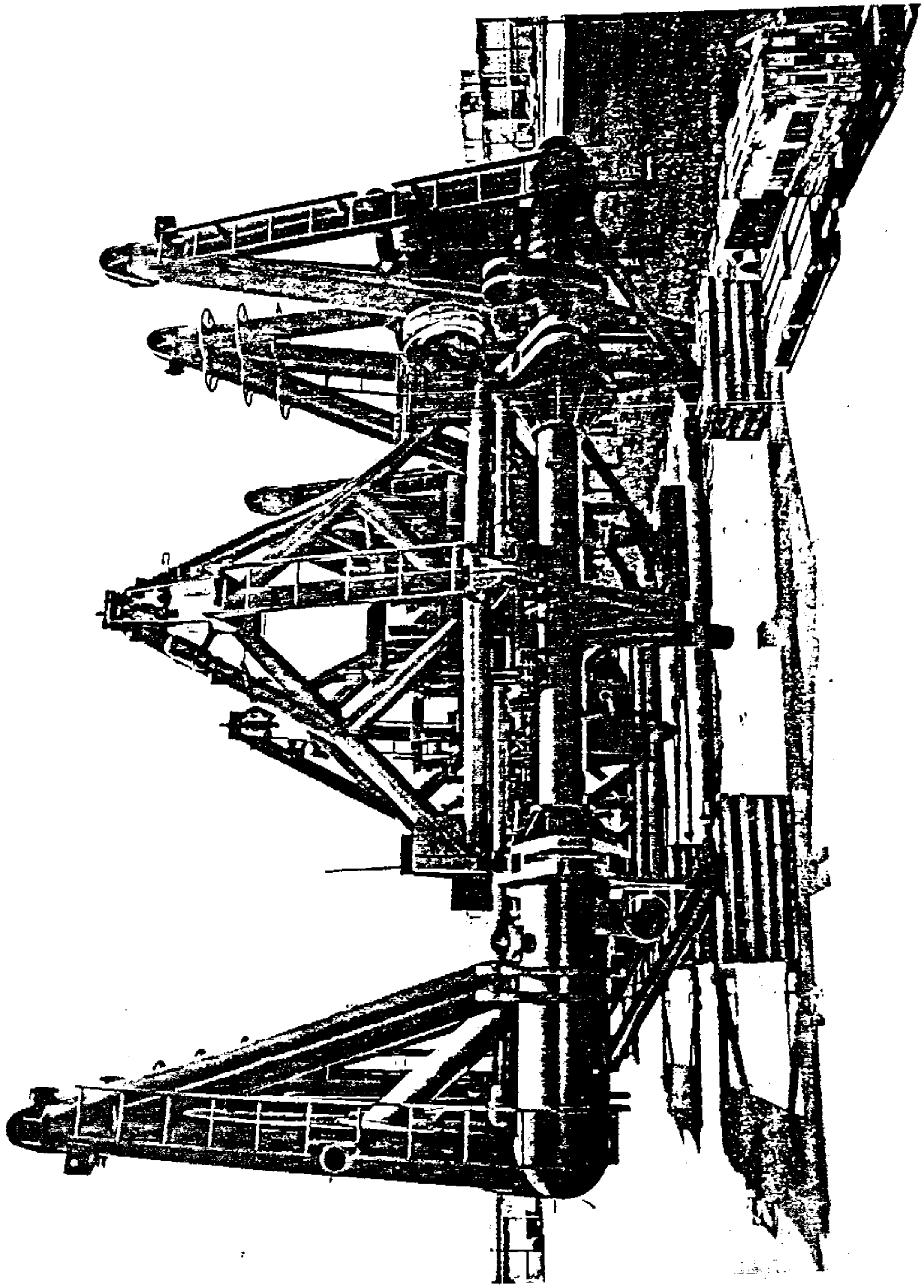


Fig. 5.19. Complex 13 launcher at ETR
(Source: Atlas D/SLV launchers (VAFB VS ETR) undated, unknown source, document found in Launch Operations Building, December 1992)

existing tank (photos. CA-133-1-B-269 through B-271, B-70, B-76). Two relocated nitrogen vessels (148 and 160 cubic feet) replaced smaller 5.3- and 6.2-cubic-foot vessels. Two other relocated vessels (28- and 38-cubic feet; 7,300 pound-per-square inch) were added to support the launcher hold-down mechanism (photos. CA-133-1-B-269, B-271). The liquid oxygen subcooler used for topping the Atlas oxidizer tank was reconnected because lower engine inlet temperatures identical to those of the SLV had to be maintained for the Atlas H propulsion system (photos. CA-133-1-B-268, B-271).

Additional television and motion picture camera towers were located on and adjacent to the launch deck (photos. CA-133-1-B-275, B-276, B-7, B-8, B-11 through B-14). The television stations and camera towers are identical to those already on site, except some camera enclosures that were salvaged from ABRES-A. In 1983, seven additional helium vessels totaling 602.4-cubic feet were added to increase capacity (photo. CA-133-1-B-269).

SLC-3W Modifications

Thor Series

Between July 1963 and October 1963, SLC-3W was converted to launch Thrust Augmented Thor (TAT)/Agena vehicles. The total cost for the modification, which was performed mostly by American Machine and Foundry, Inc.[4], was approximately $204,000. Design drawings for these modifications were not available. Since the Thor was very similar to the Atlas delivery vehicle, changes of the MST were minimal. During April 1967, SLC-3W was converted to launch the Long Tank Thrust Augmented Thor (LTAT). Photograph CA-133-1-C-144 shows that the hydraulically operated doors between stations 21 and 124, the air-conditioning system at Station 30 (photos. CA-133-1-C-21, C-22), and the interior plastic and corrugated sheet metal siding were installed prior to March 1967, even though no record of their installation could be found. Since the design and configuration of the doors and other additions are identical to modifications of the SLC-3E MST made in 1965, it is suspected that these modifications occurred at the same time (photos. CA-133-1-C-1 through C-15). The notable exception is that the SLC-3W MST incorporated the hydraulically operated doors between stations 21 and 70.5 (photo. CA-133-1-13); whereas, these doors were not added on the SLC-3E MST until 1976.

Modifications of the MST service platforms to support the LTAT were minor (photo. CA-133-1-C-144), consisting primarily of removing the folding platform sections at stations 21, 30, 39, and 63; adding new or modified hinged platforms at stations 12, 21 (photo. CA-133-1-C-146), and 55 (photo. CA-133-1-C-145); modifying the platforms at Station 70.5 to increase the central opening; and providing a cutout in the hinged platform at Station 93. The final configurations of the platforms at stations 12 through 63 are shown in photographs CA-133-1-C-146 and C-147. Aircraft warning lights were relocated from the corners of the top of the

MST to a central location, and a new coat of polyurethane insulation was added to the interior (photos. CA-133-1-C-144, C-147).

Several minor modifications of other features of SLC-3W were made to support the Long Tank Thrust Augmented Thor. Some modifications improved procedural efficiency. Modifications included adding a permanent concrete pad for two RP-1 fuel tanks that had been placed on site sometime between 1963 and 1967 (photo. CA-133-1-C-162); adding solid blast deflectors to the launch pad (photo. CA-133-1-C-161) to reduce damage from the solid rocket motors used on some models of the Thor vehicle; relocating an emergency exit to the liquid oxygen storage area (photo. CA-133-1-C-162); and the adding or relocating several power receptacles on the launch deck (photo. CA-133-1-C-160). Associated with the Thor modifications, the LSB was extended to incorporate an underground check-out facility. Lockheed Missile and Space Corporation, the Agena contractor, had been using a portable canvas-covered shelter to perform prelaunch testing of Agena vehicles. The repeated need to set up the shelter and move consoles between the LSB and the portable shelter interfered with work schedules between operations contractors at SLC-3. The new facility eliminated the portable shelter and greatly improved the efficiency of the prelaunch procedures. Construction of the check out facility started in July 1967 and was completed in January 1968. A 61.25-foot long by 31.88-foot wide extension was built onto the north face of the LSB and under the launch deck (photo. CA-133-1-C-157).

A transfer area shelter perpendicular to the check out facility was constructed to facilitate removing the Agena from its delivery trailer (photos. CA-133-1-C-157, C-158, C-65). A paved area was constructed from the existing road to the transfer shelter (photo. CA-133-1-C-157). The area under the launch deck along the north wall of the LSB was excavated, a 6-inch reinforced concrete slab was poured, and walls 15-inch thick were added (photo. CA-133-1-C-159). A retaining wall was constructed on the north side extending westward to hold back the earth fill. The transfer shed was constructed of heavy, structural-steel framing overlaid with sheet-metal siding (photo. CA-133-1-C-158). The north retaining wall was integral to the north wall of the transfer facility. The transfer facility remained open on its west face. Two transverse monorail hoists with capacities of 2-tons each were located central to the facility (photos. CA-133-1-C-158, C-142).

In 1984, the check out facility and transfer area shelter were converted to office space and breakrooms (photo. CA-133-1-C-169). The open west face of the transfer facility was sided with sheet-metal, and a 14-foot metal roll-up door and a 3-foot personnel door were incorporated (photo. CA-133-1-C-170).

Atlas E/F Series

Between September 1972 and August 1973, SLC-3W was modified to the Atlas E/F configuration. The modifications, accomplished by the contractor Smith-Hardeman under contract to the U.S. Army Corps of Engineers, were very similar and, in many cases, identical to those already discussed for the Atlas E/F conversion of SLC-3E. The most notable differences were in the central openings in stations 70.5, 78, and 85.5–the payload stations. The SLC-3E MST had fixed openings of 102 inches in diameter (fig. 5.5); whereas the SLC-3W MST was configured with a 138-inch central opening (fig. 5.20; photo. CA-133-1-C-150). "A" and "B" inserts reduced the diameter to 102 and 82 inches, respectively, except at Station 85.5, where the "B" insert reduced the diameter to 66 inches (fig. 5.20; photo. CA-133-1-C-37). Using inserts rather than a single, fixed-diameter opening allowed the MST to accommodate a wide variety of space vehicles. The folding platforms at stations 48 and 55 were completely removed (photos. CA-133-1-C-150, C-149), and handrails were constructed around the opening for safety. The folding platforms at stations 12, 21, 30, and 63 were constructed identical to those in the SLC-3E MST (fig. 5.20; photos. CA-133-1-B-194, C-18, C-26). The Station 39 folding platforms were identical at the two pads except for the quadrant I folding platform that was omitted from the SLC-3E MST. A manual pressurization system for the delivery vehicle was added at Station 3, and a payload pressurization system was added at Station 78 (photo. CA-133-1-C-151), as at the SLC-3E MST. During 1973, the west exterior face (elevator side) of the SLC-3W MST was completely enclosed with corrugated sheet metal, and the remaining open portion of the south face (quadrant I) was enclosed with corrugated sheet metal in 1975. Also in 1975, the central openings at stations 70.5, 78, and 85.5 were reduced to 102 inches, identical to those of SLC-3E, through welded structural members and plates (photos. CA-133-1-C-152, C-153, C-20; fig. 5.6); the 82-inch inserts were retained.

Other modifications of SLC-3W for the Atlas E/F configuration were identical to those discussed for SLC-3E (photos. CA-133-1-C-172, C-173). The one notable exception is that the launch pad support structure was not relocated from another facility but was designed and engineered as an original construction. Surplus items from the ABRES-A complex were used extensively. The launch pad framing, solid rocket motor blast deflectors, and most of the decking for the Thor configuration were removed (photo. CA-133-1-C-176). Sections of the flame bucket were cut away, and rectangular cutouts were removed from the forward part of the flame bucket. New decking anchor points and structural framing were added to support the Atlas E/F launches (photos. CA-133-1-C-174, C-175). The space and delivery vehicle propellant and service ducting and tubing were reconfigured to match the Atlas E/F requirements (photos. CA-133-1-C-178, C-177).

The launcher was salvaged from ABRES-A2 (fig. 5.21) and modified to accommodate the requirements of SLC-3W and the Atlas E/F delivery vehicle (fig. 5.18; photos. CA-133-1-C-59, C-60). Additions of the topping liquid oxygen tanks, Skid 9A, and the four nitrogen vessels were identical to those performed at SLC-3E (photos. CA-133-1-C-179 through C-181, C-68, C-74). All tanks, skids, and vessels were transferred from ABRES-A2. The pressurization control units, dynamic checkout unit, hydraulic pumping unit, and nitrogen supply panel were either refurbished originals or were surplus items from ABRES-A. The logic and

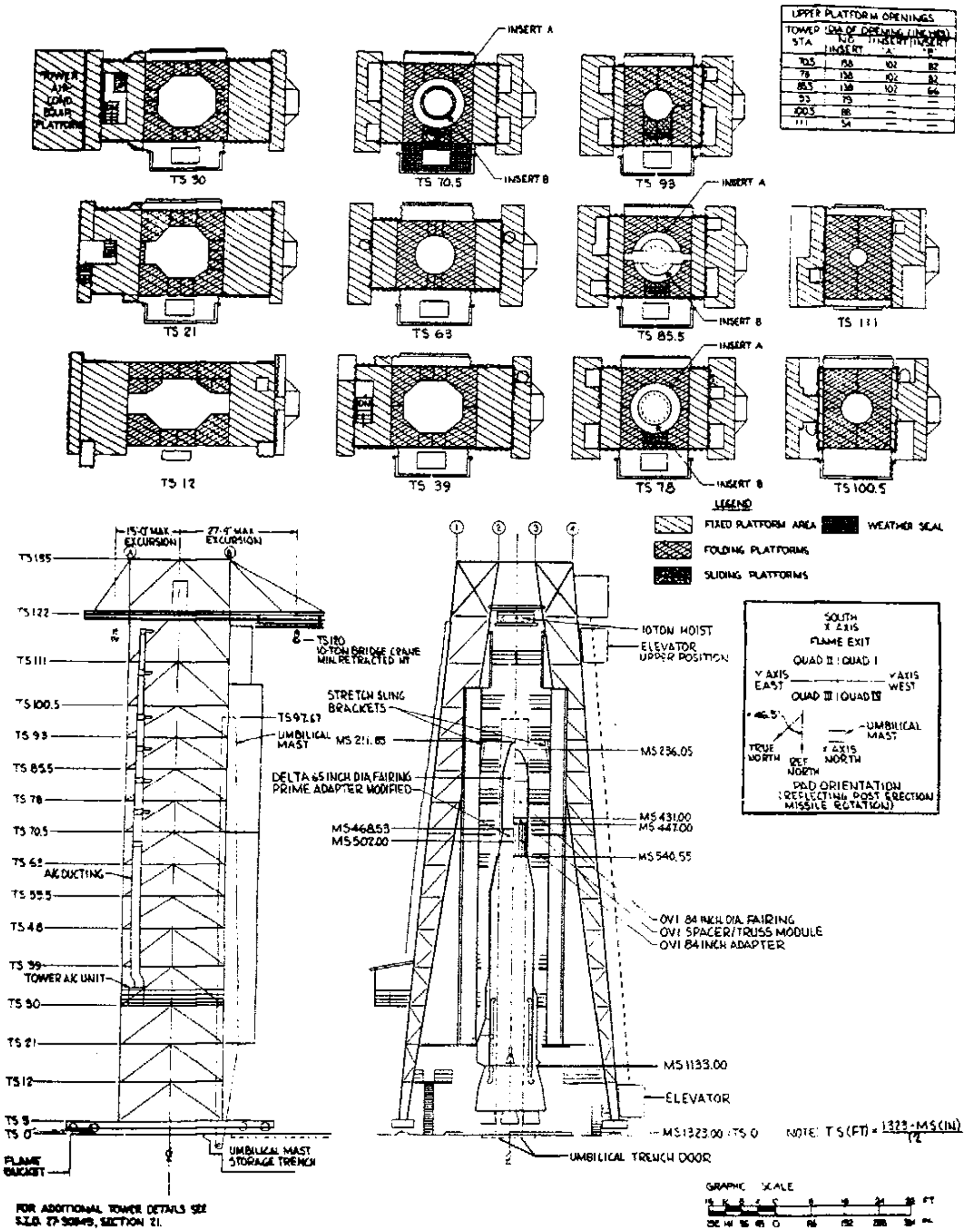


Fig. 5.20. SLC-3W service tower
(Source: General Dynamics, Report No. CASD/LVP 74-075 "SLC-3E Atlas E/F Conversion Study," January 14, 1975)

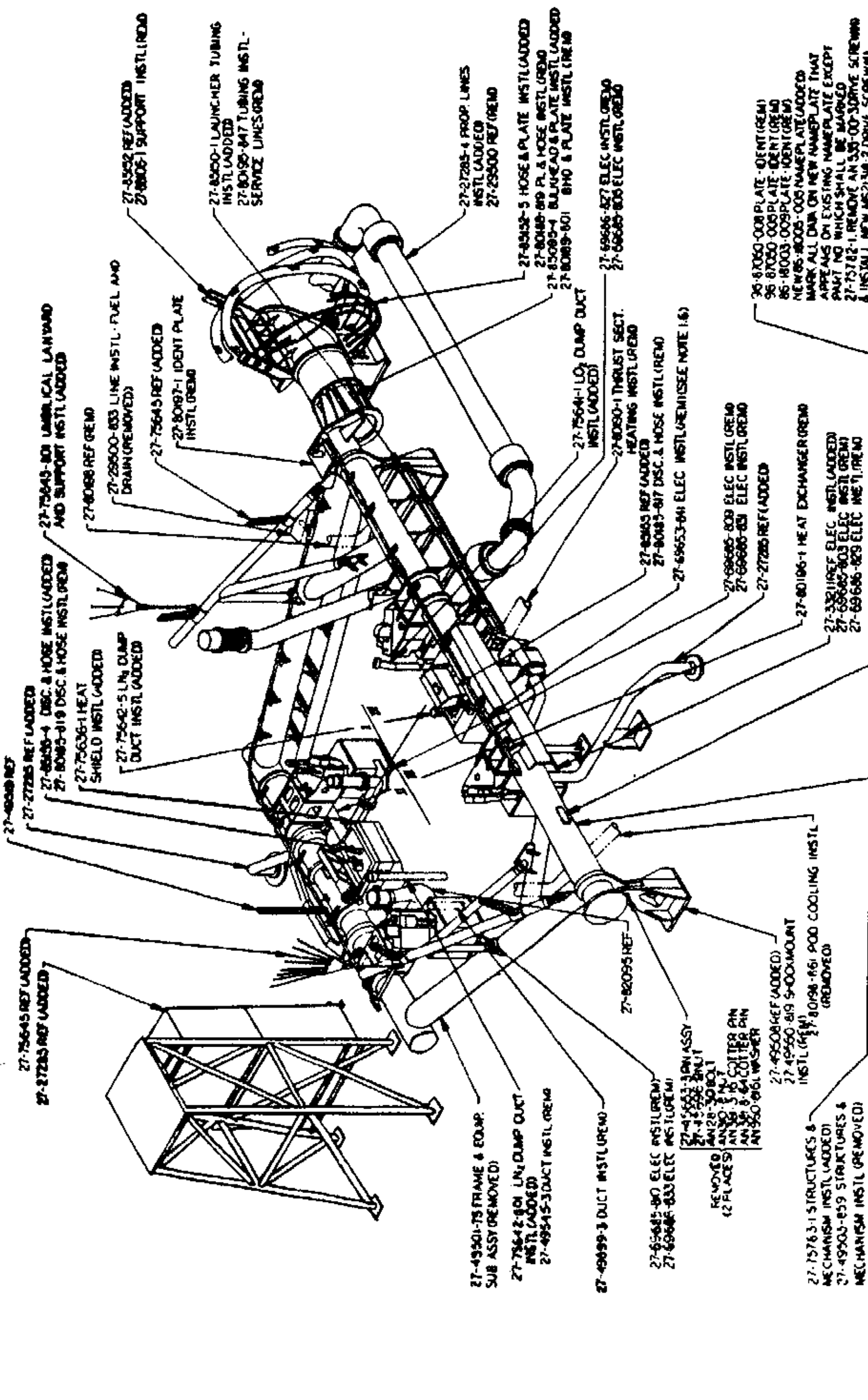


Fig. 5.21. ABRES-A2 launcher prior to SLC-3W modification

interconnections were identical to those at SLC-3E. The original fuel storage tank was removed and replaced with a tank salvaged from 576-B. A 3-foot 7-inch retaining wall was constructed around the tank to contain any leakage (photos. CA-133-1-C-182, C-81). The liquid nitrogen storage tank/helium heat exchanger, and ullage tank were salvaged from ABRES-A and installed in the LSB identically to SLC-3E (photos. CA-133-1-C-183, C-136). Valve and control Skids 1, 2, 5, 7, and 9 received new metal enclosures to protect the valves and controls from the elements (photo. CA-133-1-C-184). The Atlas E/F reconfiguration included additional power and instrument wiring at the liquid oxygen area, fuel area, and within the LSB.

The MST was modified in 1977 to accommodate the *SEASAT* payload by enlarging the central opening at Station 63 to 11 feet 6.5 inches (photo. CA-133-1-C-154); relocating the 3-ton bridge crane from the SLC-3E cupola to the SLC-3W MST at Station 124 for use as an auxiliary hoist (photo. CA-133-1-C-155), making it identical to the east MST; adding a payload tent (photo. CA-133-1-B-211) and an auxiliary air-conditioning duct from the umbilical mast trench to the payload station (photo. CA-133-1-B-200; fig. 5.6); and converting the sliding platform at stations 70.5 through 93 to hydraulic actuators (photos. CA-133-1-B-196, C-33). Other minor modifications or additions were identical to those at the SLC-3E MST. These included: adding an emergency shower at Station 70.5 in 1976 (photo. CA-133-1-C-156); adding a fire resistant coating (photo. CA-133-1-B-198) at stations above 70.5 in 1976; adding a bottled personnel air supply system at stations 70.5 and 78 (photo. CA-133-1-B-207) in 1979; and reinforcing the MST (photos. CA-133-1-B-205, B-206) in 1979.

Several minor modifications of SLC-3W were performed after the conversion to the Atlas E/F configuration. A trichloroethylene recovery system was added in 1973. The delivery vehicle engines required flushing with trichloroethylene prior to fueling. For environmental reasons, it was no longer acceptable to purge the trichloroethylene to the atmosphere. Three 4-foot 5-inch diameter aluminum funnels with band clamps were fabricated to fit over the engine exhaust nozzles (photo. CA-133-1-C-163). The funnels were manifolded and ducted to a 350-gallon tank (photo. CA-133-1-C-164). The flame bucket was repaired in 1975, and a new 5-inch thick coat of refractory concrete was added (photo. CA-133-1-C-165). A water deluge system identical to the one at SLC-3E was added to the flame bucket in 1976 (photos. CA-133-1-B-259, C-65, C-86), and a helium/nitrogen pumping station was added in 1980 (photos. CA-133-1-C-166 through C-168). In 1984, a monorail hoist beam with a trolley was added to Room 116 of the LSB (photo. CA-133-1-C-171). A hoist was attached as necessary.

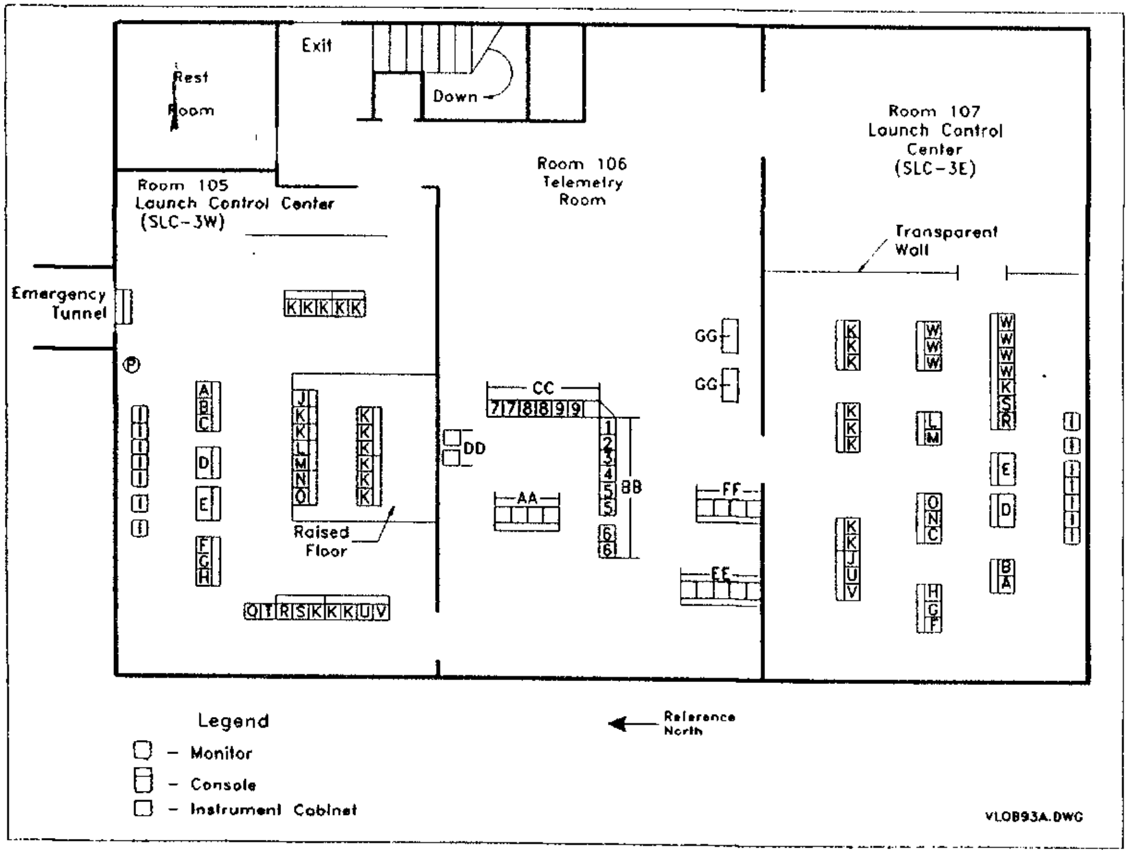
Launch Operations Building (Blockhouse, Building 763)

The Launch Operations Building (Blockhouse Bldg. 763) is the site of monitoring and operations during the final stages of a launch from either pad. The Launch Operations Building (LOB) is a two-story bunker located immediately inside the SLC-3 perimeter fence, east of and roughly equidistant from the two launch pads (fig. 5.4; photo. CA-133-1-A-2). The street level of the LOB currently houses separate control rooms for each pad and a central area containing radio telemetry and guidance systems, propellant utilization monitoring equipment, and payload patchboards (fig. 5.22). The basement level houses the autopilot, landline instrumentation, and communication equipment for the two pads, and air-conditioning equipment for the building (fig. 5.23).

The LOB is constructed of reinforced, poured concrete and surrounded by an earthen embankment on the north, south, and west sides, as well as above the roof. The embankment provides protection from blast damage. The earth fill distributes impact forces and explosive blast forces uniformly throughout the structural shell, thereby increasing the potential for survival of the structure and its occupants in case of a catastrophic launch failure. The original structure was 64.33 square feet. The exterior concrete walls are 16-inches thick; the concrete roof is 12-inches thick.

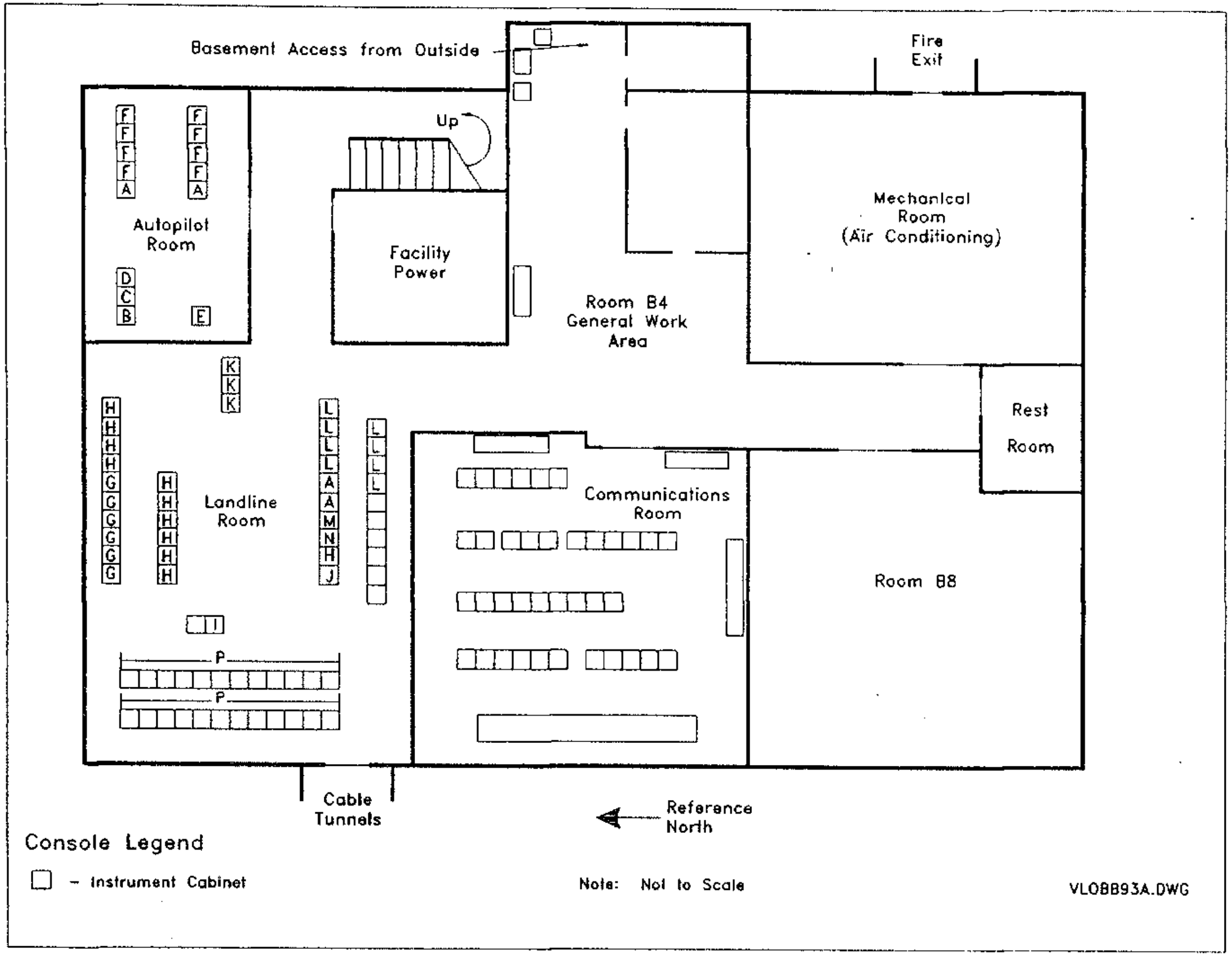
The east face of the structure is a concrete facade 5-feet high and 12-inches thick that serves as a retaining wall for the earth fill on top of the LOB (photos. CA-133-1-A-1, A-110). A 40-foot retaining wall extends eastward from the east face of the LOB at the south corner. A similar retaining wall is set 16 feet 8 inches south of the north corner of the bunker. These retaining walls support the earth of the embankment along the sides of the LOB (photos. CA-133-1-A-118, A-109). An areaway 26.33 feet long by 9.17 feet wide by 17.2 feet deep between the street and basement levels originally provided access and ventilation to the basement mechanical room (originally Room B-4; photos. CA-133-1-A-109, A-110, A-118). A jib crane with a one-ton-capacity, hand-operated hoist is located above the areaway to facilitate equipment removal. The areaway also provided an escape route from the basement of the LOB to the east side of the bunker via a steel ladder set into the inner face of the areaway.

A 12-foot 4-inch by 16-feet 10-inch, reinforced concrete vault (Room B-6, cable shaft) extends to a height of 16 feet 4 inches from the basement level on the west face of the bunker (photos. CA-133-1-A-118, A-109). Corrugated metal tunnels approximately 8 feet in diameter connect the vault to cable shafts located 55 feet to the north and 65.5 feet to the south. In the cable tunnels, 12-inch wide trays bracketed to the metal walls carry electrical cables to the shafts, where they rise vertically to the surface and extend north and south toward the launch pads. Originally both shafts exited through corrugated metal sheds (photos. CA-133-1-A-2, A-4). Access to the cable tunnels is available both from inside the LOB (Room B-6) and from the cable shed. A 3-foot 6-inch wide wooden plank floor lines the corrugated metal tunnels for safety. All electrical equipment rooms and the original control room have raceways beneath the floor for electrical cable. Removable wooden floor panels in these rooms provide access to the raceways (photos. CA-133-1-A-109).



A - Booster Power Monitor
B - Facilities Control
C - TV Camera Control
D - Launch Analyst Panel
E - Launch Operator Panel
F - Battery Monitor
G - Range Safety
H - Operations and Check Out
I - Video Monitor
J - Complex Safety
K - Payload Control
L - Asst. Launch Controller
M - Launch Controller
N - Asst. Launch Conductor
O - Launch Conductor
P - Periscope
Q - Air Force Weather Monitor
R - Payload Environment Monitor
S - PECMP
T - Chart Recorder
U - Camera Control
V - Camera Patch/Power
W - Agena Controls
AA - Radio Frequency Control
BB - Demultiplex Bay
1. power supply
2. frequency generator
3. demultiplexor
4. patch panel
5. oscilloscope
6. tape recorder
CC - Analog Record Bay
7. oscillograph
8. CRT/chart recorder
9. chart recorder only
DD - Loral ADS 100A Quantizer
EE - Propellant Utilization Test Set
FF - Airborne Beacon Electronic Test Set
GG - Payload Patch Panel

Fig. 5.22. Plan view of street-level of the Launch Operations Building (Bldg. 763)



A - Honeywell "visicorder" optical chart recorder
B - Location 25
C - Location 26
D - Location 24
E - IBM PC
F - Gould Brush chart recorder
G - Power distribution unit
H - Esterline Angus chart recorder
I - Patchboard
J - Autopilot patchboard
K - Granetz "event recorder"
L - Gould Brush chart recorder
M - U313
N - U305
P - Cable distribution unit

Fig. 5.23. Plan view of basement level of the Launch Operations Building (Bldg. 763)

A 5-foot wide by 39-foot long, reinforced concrete escape tunnel extends north from the street level through the embankment and exits on the north face of the bunker (photo. CA-133-1-A-3). Access to the tunnel is through a steel, blast-resistant door in the north wall (Room 105).

Interior room partitions vary in construction between concrete block, wood studding, and metal/glass combinations (photo. CA-133-1-A-109). None of the interior partitions are load bearing. All structural loads and potential blast forces are borne by the exterior walls, nine reinforced concrete columns set in oversized footings, and reinforced concrete risers. The original Control Room (Room 105) has a 12-inch, raised, wooden platform to elevate the primary command and control consoles.

Several pipe sleeves penetrate the roof of the LOB to provide cable access and attachment points for television cameras, antennae, and a bunker periscope (photos. CA-133-1-A-1, -A-2) located in the original Control Room (Room 105). Steel shrouds encasing the pipe sleeves provide support and prevent the earth fill from contacting the sleeves. The LOB is equipped with convential lighting and fire alarm systems (photo. CA-133-1-A-112).

Prior to 1964, SLC-3E and SLC-3W were controlled from one room on the street level: the present SLC-3W Control Room (Room 105). The second Control Room (Room 107) was constructed in 1964 during the only extensive modification of the LOB. During 1963, SLC-3W was converted to launch Thor vehicles under the auspices of Douglas Aircraft Corporation (later to become McDonnell Douglas Corporation); SLC-3E continued to launch Atlas vehicles under the auspices of General Dynamics Corporation. It soon became apparent that separate control rooms were needed to maintain the desired launch schedules for both pads. Separate control rooms would prevent repeated reconfiguration of control consoles for different launch vehicles and would allow the two contractors to employ different prelaunch and launch procedures, if necessary.

The LOB was expanded by 50 percent to accommodate the new Control Room. A 33-foot by 66.33-foot, two-level extension was added to the south side of the LOB (photos. CA-133-1-A-110, A-111). Openings were made in the original south wall for doorways, piping, cabling, and power circuits. Rather than using support columns that reduced usable space, as in original portions of the LOB, four 20-inch by 48-inch pillars were built into the original and new south walls to carry the roof and blast loads (photo. CA-133-1-A-114). The original, exterior south retaining wall was removed, except for a 9-foot section extending from the east face (photo. CA-133-1-A-1). A new, 40-foot retaining wall was constructed contiguous with the new south wall and extending eastward (photos. CA-133-1-A-113, A-114). An areaway leading from Room B-4 that provided ventilation and access for equipment and escape was covered with a permanent concrete slab; a 9-foot 7-inch by 7-foot 7-inch hatch in the slab provides access for equipment. The street-level extension became the Control Room for SLC-3E (Room 107), and the original Control Room (Room 105) was dedicated to SLC-3W. Removable floor panels for access to the cable raceway were added to Room 107; however, these have since been covered with vinyl tile. Room 107 was not designed to include a raised wooden platform like the one in Room 105. The plans for Room 107 show a periscope located in the southwest corner of the room; however, the periscope was never installed.

The lower level (basement level) of the extension was designed for new mechanical (Room B-10) and landline equipment (Room B-8) rooms. Although currently vacant, Room B-8 once housed control and monitoring equipment for classified payloads launched aboard Thor/ Agena boosters operated by Lockheed and for satellites operated by Rockwell International (fig. 5.23). The original Mechanical Room (Room B-4) and areaway were converted to a Payload Equipment Room, and a raised, removable floor was installed. A new chilled-water air-conditioning system (photo. CA-133-1-A-116) was installed in the new Mechanical Equipment Room, and air handlers were placed strategically throughout the LOB. Equipment parameters and operating factors for the LOB air-conditioning system are shown in (photo. CA-133-1-A-117). Room B-10 was equipped with an 11-square-foot concrete service area (Room B-11) and separate concrete ventilation shafts adjacent to the service area to replace the areaway from Room B-4. The service area was covered with a metal hatch identical to the one that covered the original areaway (photos. CA-133-1-A-114, A-115, A-1). A circular escape hatch, 2.5 feet in diameter, was incorporated into the hatch cover. The escape ladder from the old areaway was relocated to the service area (Room B-11) directly below the escape hatch. The two ventilation shafts were covered with a metal frame incorporating a metal louver for incoming air and a 30-inch duct leading over the top of the LOB for exhaust air (photos. CA-133-1-A-115, A-1). The corrugated sheet-metal shed over the south cable shaft was replaeed with a 32-foot long, 8-foot by 16-foot corrugated metal conduit over the shaft and cable trays leading toward SLC-3E (photos. CA-133-1-A-114, A-5). The entire extension was back-filled with earth and contoured to match the original LOB.

Activity in the LOB commences well before an actual launch as various electronic equipment is tested or wired to mission-peculiar specifications. Once a booster is erected on the launch pad, various tests and preparations are conducted from LSB (Bldg. 751 or 770), and monitored jointly in the LSB and the LOB. Most vital operations, such as pressurizing the delivery vehicle, payload environment, fueling, retraetion of the umbilical mast, and operating the deluge system can be monitored and controlled locally from the LSB or remotely from the LOB. Approximately two hours prior to a launch, operations are switched to LOB control. The LSB is evacuated after the MST is moved away from the delivery vehicle and secured. Once the pad is evacuated, fueling is completed and final preparations for launch proceed automatically. These final sequences are initiated and monitored in the LOB. Launch sequencing and monitoring are controlled by hardwired, analog systems of electromechanical relays. Data are read from magnetic meters and optical or ink-type chart recorders.

SLC-3E Control Room

The SLC-3E Control Room (Room 107) is located in the southwest corner of the street level (fig. 5.22). Photographs CA-133-1-A-55 through A-57 show the current complement and arrangement of control consoles in the room. Most of the consoles were manufactured in the early 1960s. The various consoles were designed and manufactured by General Dynamics, Quintron Systems, Inc. (Quintron), and Lockheed. Most of the current consoles that control critical launch operations (i.e., those designed and manufactured by General Dynamics) were transferred to SLC-3 from ABRES-A (north VAFB) in 1971 in conjunction with conversion of the pads to Atlas E/F configuration. Prior to arriving at ABRES-A, these consoles may have been located at any Atlas ICBM Emergency War Order installation in the United States;[5] however, no records documenting the origins of the consoles prior to their arrival at ABRES-A are available. The original control consoles for Atlas D and SLV boosters were scrapped when the SLC-3 pads were converted to the Atlas E/F configuration. Information about the origin or appearance of the original consoles is not available.

Most consoles in the room are equipped with communications panels designed and manufactured by Quintron (fig. 5.24). This communications equipment was installed during the mid-1970s. Photograph CA-133-1-A-59 shows a typical communications panel at the bottom of an otherwise blank console. The panels typically contain twenty switches corresponding to channels in the SLC-3 communications network, two ports for attaching headsets, a touch-tone key pad, and volume controls. Several consoles are equipped with pedals that control the mouthpiece on the headset, allowing the operators' hands to remain free (photos. CA-133-1-A-73, A-78).

A network channel is monitored by pushing its switch up. The console operator can speak over a channel by pushing its switch down and activating the headset mouthpiece with either the switch on the headset cord or the pedal. Any number of channels can be monitored simultaneously, and several channels can be monitored while speaking over one or more other channels; however, it is not possible to monitor and speak on a channel at the same time. Two of the twenty channels are commercial telephone lines, and the touch-tone key pad allows the console operator to place an external call while monitoring or speaking on other network channels. The Complex Safety, Launch Controller, and Assistant Launch Controller consoles (fig. B; photos. CA-133-1-A-61, A-65) each have thirty-channel communications panels. The additional channels provide access to other VAFB buildings outside of SLC-3.

There are several other minor variations in the communications equipment. On the console containing the Launch Operator Panel (LOP) and the Launch Analyst Panel (LAP), the communications panels are located beside the panels rather than at the bottom of the panels. These panels have rotary dials for making external calls rather than touch-tone key pads. Photographs CA-133-1-A-73, A-78 show the LOP and LAP communications panels. Several

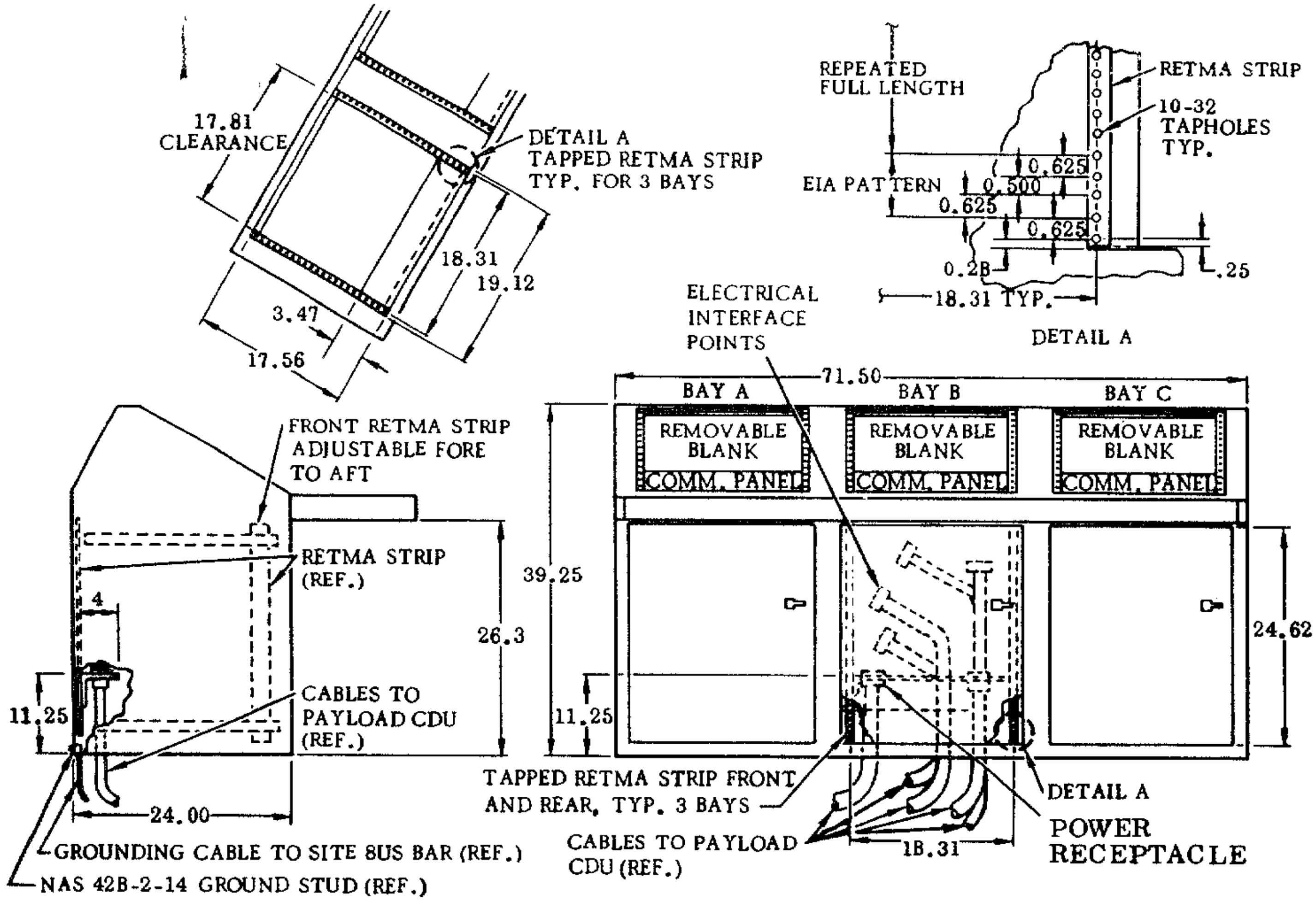


Fig. 5.24. Schematic of typical control consoles in the Launch Operations Building (Bldg. 763)
(Source: General Dynamics, Report No. CASD/LVP 77-055 "Standardized Atlas Launch Vehicle System for Orbital Missions," December 1977)

consoles are equipped with amplifiers for "slave" communications panels. Slave panels have no switches for direct access to network channels and are controlled by the adjacent full panel. An amplifier and an adjacent slave communications panel are visible in photograph CA-133-1-A-71.

Although individual consoles frequently underwent minor modifications as part of routine maintenance, arrangement of consoles in the SLC-3E control room has remained nearly the same throughout its history. The consoles are arranged according to function so that the critical launch operations are coordinated from the center of the room, and support functions are arranged around its perimeter. In the following paragraphs, the functions of consoles and other equipment in the SLC-3E control room are described in full detail beginning with the row of consoles nearest the north wall and proceeding from east to west in each row (fig. 5.22).

The series of blank consoles in the row nearest the north wall (fig. 5.22-"K"; photos. CA-133-1-A-55, A-58 through A-60) accommodated payload control and monitoring panels unique to each payload program. Program- or mission-peculiar equipment was installed in these consoles and operated by the agencies or contractors responsible for the payloads.

The westernmost consoles in the row nearest the north wall still contain equipment panels. The first (easternmost) of these (fig. 5.22-"J"; photo. CA-133-1-A-61) is the Complex Safety console designed and manufactured by Quintron Systems, Inc. This console contains control switches for the system of warning lights and sirens located around the complex. Separate switches are provided for lights and evacuation sirens at the west pad, east pad, and LOB. Warning lights are arranged in groups of three: the green light indicates that the area is safe ("all clear"); the amber light indicates a potentially hazardous condition, such as a pressurized vehicle on the pad, fueling in progress, or movement of large equipment (e.g., booster, payload, MST); the red light indicates a dangerous situation, such as extremely high pressures in a system on the pad. The combination of a siren and the red warning light is the signal to evacuate and indicates a life threatening situation in the area. Complex Safety warning lights are located on the south wall of the east pad control room and are visible in the upper left corner of photograph CA-133-1-A-81. There are two sets of warning lights in the room, one for the east pad (labeled "Pad 2" in reference to the historic name for SLC-3E when the complex was known as PALC-1) and one for the LOB. The red warning light is on the top of the rectangular stack of lights, amber in the middle, and green on the bottom.

The last two consoles in the first row (fig. 5.22-"U" and "V"; photo. CA-133-1-A-62) control high-speed still cameras located around SLC-3E. The first console (fig. 5.22-"U"; photos. CA-133-1-A-62, A-63) contains a patchboard for selecting which of the forty-eight available cameras will be operated during the launch. Cameras can be arranged in two sets--those that will be operated fifteen seconds prior to launch and those that will be operated five seconds prior to launch. Separate switches for each camera enable the cameras and retain them in pause status until the master switch for the set is activated. The adjacent console (fig. 5.22-"V") contains signal conditioners for the high speed cameras. These consoles were manufactured by Quintron Systems, Inc.

The console nearest the east wall in the center row (fig. 5.22-"W"; photo. CA-133-1-A-64) once contained panels for the Agena, operated by Lockheed. The Agena was a second-stage booster or satellite bus used in several satellite programs launched from SLC-3E. The Agena was fueled with hydrazine and red fuming nitric acid instead of the RP-1 and liquid oxygen used to fuel the Atlas. This console and others labeled "W" in figure 5.22 have not been used since the last Agena launch from SLC-3E in 1968; they were designed by Lockheed Missile and Space Corporation. The switches visible in the center panel of the console (photo. CA-133-1-A-64) controlled fueling and launch sequencing for the Agena.

The next console in the center row (figs. 5.22-"L, M"; photos. CA-133-1-A-55, A-65) contains the Launch Controller and Assistant Launch Controller panels. These panels are operated by Air Force personnel responsible for maintaining communication with the Air Force Launch Control Center in the main Air Force building on north VAFB. The switches on the Assistant Launch Controller panel select and enable television cameras that allow staff in the Air Force Launch Control Center to monitor the east pad. The Assistant Launch Controller panel also contains the controls for setting the countdown clock, which is set on orders from the Air Force Launch Control Center. The Launch Controller panel contains the switches for a set of warning status lights located in the Air Force Launch Control Center. The Launch Controller's primary responsibilities are to verify the completion of all procedures in the appropriate sequence during a launch or wet dress rehearsal (simulated launch sequence in which liquids and gases are loaded aboard the delivery vehicle) and to relay information about testing or launch operations occurring in the SLC-3E control room to the Air Force Launch Control Center.

The critical components of the Launch Control System are operated and monitored from four consoles located centrally in the SLC-3E control room: the Launch Conductor Console (LCC; fig. 5.22-"O"), the Launch Operator Panel (LOP; fig. 5.22-"E"), the Launch Analyst Panel (LAP; fig. 5.22-"D"), and the Facilities panel (fig. 5.22-"B"). These consoles were designed and manufactured by General Dynamics. The Launch Conductor (or Test Conductor) Console is the focal point of launch operations (photos. CA-133-1-A-56, A-66). The Launch Conductor directs the sequence of the Launch Control System, which has four significant phases: standby, countdown, commit, and commit-stop/automatic abort.

Standby is the phase immediately prior to countdown during which all systems on the booster (i.e., engine and booster ground power, hydraulics, liquid nitrogen and helium, fuel, and liquid oxygen) are verified as prepared for launch. Standby preparations consist of ensuring that valves and circuit breakers are in the proper position, the quantity and quality of liquids and gases are appropriate for transfer, and fueling of the delivery vehicle is complete. The status of all systems on the delivery vehicle is monitored by standby indicator lights on the LOP (photos. CA-133-1-A-73, A-74) and LAP (photos. CA-133-1-A-73, A-75 through A-77).

Countdown is the process of initiating and sequencing the booster systems to the "ready-for-commit" point. Countdown begins between thirty hours and five hours prior to launch. During countdown, the delivery vehicle buses are energized; ground hydraulic pressure is supplied to the delivery vehicle; liquid nitrogen, helium, and liquid oxygen are loaded into the delivery vehicle tanks; and the autopilot and guidance systems are tested. Controls for initiating and sequencing the pressurizing and loading systems are located on the LOP (photo. CA-133-1-A-74). The appropriate sequence of operations for each system is hardwired into the controls. The logic, or wiring, of the LOP disables the button that initiates the next step in the countdown sequence for each system until lights indicating successful completion of the prior step are illuminated. The Launch Operator initiates the next step in each sequence by depressing the appropriate button on the LOP at the specific direction of the Launch Conductor. Countdown events are monitored in detail on the LAP (photos. CA-133-1-A-75 through A-77) via lights that indicate current status of the systems, pressures in the systems, and significant increments in the percent of filling of fuel and liquid oxygen tanks (i.e., 90 percent, 95 percent, 100 percent). A summary of countdown events is displayed on the first (easternmost) panel of the LCC (fig. 5.22-"O"; photo. CA-133-1-A-66).

The commit sequence may be initiated when all systems have reached ready-for-commit status and the "commit ready-to-start" indicators on the LOP and LCC illuminate green. Commit is initiated by depressing the "commit-start" button on the LCC. The LOP is equipped with a redundant commit-start button; however, it should not be depressed except at the direction of the Launch Conductor. Significant events in the commit sequence are displayed by indicators on the LOP, LAP, and LCC. The commit sequence is automatically controlled by the Launch Control System relay logic. During the commit sequence, the booster electrical system is transferred from ground to internal power (i.e., main vehicle battery); the mast-retract system is armed; the liquid oxygen tank is pressurized to flight pressure and topped; pneumatics are transferred to internal pressurization; and the engine start sequence is initiated. For the Atlas H vehicles last launched from SLC-3E, a hold-down system anchors the booster to the launcher until all three engines (i.e., two boosters, one sustainer) are ignited and generating at least 90 percent thrust. The mast-retract and umbilical-eject signals are generated during this process. The mast-retract system is enabled and monitored at controls on a panel of the Facilities console (fig. 5.22-"B"; photo. CA-133-1-A-79).

The commit-stop sequence consists of a series of operations that either return the vehicle to ready-for-commit status prior to launch or return the launch pad to a safe configuration after the launch; this involves purging the liquid and gas delivery systems to prevent foreign objects from contaminating the lines and shutting off nonessential electric power to the pad. The stop sequence is initiated by depressing the "commit-stop" button on the LCC. The LOP is equipped with a redundant commit-stop button. The stop sequence can be initiated at any point in the commit sequence prior to the engine-start signal. Commit-stop is disabled from the time the engine-start signal is sent until five seconds after the engines were supposed to have developed sufficient thrust for launch. The Launch Control System logic automatically initiates an abort (commit stop) signal if the five-second limit elapses without achieving sufficient thrust for launch.

The panel immediately adjacent to the LCC in the center row of consoles (fig. 5.22-"N"; photo. CA-133-1-A-66) is the Assistant Launch Conductor panel. It is equipped with a weather monitor with an LED display designed and manufactured by ITT Federal Electric Corporation (now ITT Federal Services Corporation). The monitor, installed new in 1984, displays wind direction and speed measured at heights of 12 and 54 feet on the meteorological tower located between SLC-3E and SLC-3W (fig. 5.4 - adjacent to Bldg. 756). The monitor can display either average wind speed or gust speeds.

The last panel in the LCC controls six television cameras located around the pad (fig. 5.22-"C"; photo. CA-133-1-A-67). The panel is equipped with switches for controlling the focus, direction, and speed of movement of each camera. The camera locations are labeled: 1-Flame bucket, 2-Fuel Apron, 3-Fuel II, 4-Liquid Oxygen Tower, 5-Liquid Oxygen Apron, and 6-LOB Roof. Cameras 1 through 5 have corresponding black and white monitors mounted on the south wall of the SLC-3E control room (fig. 5.22-"I"; photos. CA-133-1-A-56, A-80, A-81). These monitors, manufactured by Conrac, were installed new in 1974 to replace older models. Between 1986 and 1987, camera 6 and its monitor were installed, and an additional monitor labeled 7-Video Switcher was installed; these two color monitors were manufactured by Videotek.

The last console in the center row contains three panels: the Operations and Checkout panel, the Range Safety panel, and the Battery Clock panel (fig. 5.22-"H, G, F"). This console is unique from others in the room because it has an independent power supply located in the cabinets immediately below the three panels (photo. CA-133-1-A-68). The independent power supply reflects the function of this console, which is to control and monitor nonessential systems that, when airborne, are powered by individual batteries rather than by the main vehicle battery.

The Operations and Checkout panel (fig. 5.22-"H"; photo. CA-133-1-A-69, left) is used to switch the telemetry and destruct systems and the C-band beacon (for tracking if the telemetry system fails) to their internal batteries and to monitor the voltage of those batteries. The cabinet below this panel contains the power control and relay logic for the three panels in this console (photo. CA-133-1-A-68).

The Range Safety panel (fig. 5.22-"G"; photo. CA-133-1-A-69, right) monitors the condition of the on-board destruct system, which is operated from the Air Force Launch Control

Center in the main Air Force building on North VAFB. The destruct system consists of an explosive charge mounted on the bulkhead between the RP-1 and liquid oxygen tanks; it is detonated via a radio signal, rupturing the bulkhead and allowing the fuel and liquid oxygen to mix. The panel contains gauges for monitoring the strength of the signal reaching the vehicle from the destruct system. The cabinet below this panel contains switches to control the distribution of power to the three panels in the console.

The Battery Clock panel (fig. 5.22-"F"; photo. CA-133-1-A-70) contains separate gauges that display the amount of time remaining until the power is exhausted in each of four auxiliary batteries on the booster: the telemetry system battery, the C-band beacon battery, and separate batteries for each of the two, redundant destruct signal receivers. The cabinet below this panel contains switches for testing the indicator lights on each of the three panels in the console.

The first console in the row nearest the south wall of the SLC-3E Control Room contains panels for controlling and monitoring the payload air-conditioning system. The Payload Environmental Control Monitoring Panel (PECMP; fig. 5.22-"S" and "R"; photo. CA-133-1-A-72) is actually a pair of panels labeled Location 128 and Location 129. The gauges on Location 128 monitor the pressures associated with a variety of components of the payload air-conditioning system. The payload air-conditioning system comprises two subsystems that provide clean, heated, or cooled air to the payload via the umbilical mast. The flow rate and temperatures produced by each system can be adjusted either from SLC-3E LSB (Bldg. 751) or from Location 128 on the PECMP; the relative humidity in the payload area is controlled indirectly by adjusting the temperature of air reaching the payload. The PECMP instrumentation provides continuous monitoring of duct pressure, temperature, and relative humidity near the outlets to the payload area during checkout, standby, and launch operations. The bottom panel at Location 128 controls the backup air-conditioning system. Location 129 is equipped with gauges that receive input from transducers on the MST for monitoring duct pressure, temperatures, and relative humidities for each system as well as ambient temperatures near the outlets of the systems.

The Facilities console (fig. 5.22-"B A"; photo. CA-133-1-A-79) consists of a pair of panels that monitor support equipment on the pad, MST, and the main vehicle battery. The left (east) panel on this console is equipped with controls to activate or stop the deluge systems on the pad and in the flame bucket. As noted above, the left panel also contains controls for operating and monitoring the umbilical mast. The right panel on the Facilities console (fig. 5.22-"A") controls and monitors the main battery, Atlas environmental control equipment, and the hold down/release system. The right panel is equipped with controls for the thrust-section heater, which preheats air reaching the thrust section of the vehicle to remove water, preventing corrosion and minimizing the risk of explosion. The panel also contains an inverter frequency generator that produces a 400-hertz, alternating-current signal for the air-conditioning system that serves the delivery vehicle levels of the MST. This "booster pod" air-conditioning system, reduces humidity to retard corrosion of the vehicle. The panel is equipped with gauges and switches to monitor and control electrical power reaching the delivery vehicle. The DC gauge represents the main battery and the two gyroscope batteries that are the primary internal power system for the delivery vehicle. The panel is also equipped with a temperature/current monitor with an LED display. The console operator can select a variety of functions to monitor on this display using a series coded switches (photo. CA-133-1-A-79).

Additional equipment in the SLC-3E Control Room provides ancillary information related to the launch. LED clocks displaying Greenwich mean time, countdown time, and hold time are mounted in several positions on the south wall, adjacent to the monitors (photos. CA-133-1-A-56, A-80, A-81). These clocks were installed new in 1981 to replace original odometer-type clocks. An odometer-type digital counter, located below the monitors on the south wall (photo. CA-133-1-A-80), was installed in 1982 to display the number of gallons of fuel loaded into Atlas H vehicles in real time. This counter was required because the Atlas H had a sight gauge for tracking the progress of fueling instead of the sensor probe in the fuel tank of the Atlas E/F. The fuel-level sensor in the Atlas E/F was hardwired to the display in the LOP and LAP. During Atlas H fueling, however, a technician estimated the percent of the tank filled by reading the sight gauge; this information was translated into number of gallons of fuel and relayed electronically to the counter in the SLC-3E Control Room.

The final salient features of the SLC-3E Control Room are the copper pneumatic tubing, pressure gauges, and blast damper controls for the LOB air-conditioning system that are located on the east side of the north wall (photos. CA-133-1-A-57, CA-133-1-A-82 through A-84). This equipment, manufactured by Honeywell, is original and has undergone only one minor modification since installation in 1965. The fresh-air intakes for the LOB are equipped with butterfly valves, known as blast dampers, to stop the flow of outside air into the LOB, preventing entry of noxious or toxic fumes produced during launch. The blast dampers are closed just prior to a launch either automatically using the controls in the SLC-3E Control Room (photo. CA-133-1-A-84) or manually from the air-conditioning room on the lower level of the LOB. Originally, the position-monitors for the blast dampers were connected to the pneumatic lines that operate the butterfly valves; consequently, the gauges displaying the position of the valves responded any time gas moved in the system, providing no reliable indication that the valves had actually closed. In 1986, the system was modified to allow the position of the dampers to be monitored directly with a solenoid and microswitches.[6]

With the exception of the Range Safety panel, all consoles in the SLC-3E Control Room will be scrapped in preparation for planned modifications of the SLC. The Range Safety panel will be salvaged as back-up equipment for the SLC-3W Control Room.

SLC-3W Control Room

The SLC-3W Control Room is located in the northwest comer of the street level. The most notable difference in the general design of the SLC-3W Control Room is the raised platform located against the south wall (fig. 5.22). This platform contains the LCC and Assistant Launch Conductor panel, and the Launch Controller and Assistant Launch Controller panels in one console; and the Complex Safety panel and two blank payload panels in an adjacent console (fig. 5.22-"O, N, M, L, J"; photos. CA-133-1-A-11 through A-14). The location of the LCC on this platform provides the Launch Conductor with a better view of operations at the LOP and LAP than could be achieved from a floor-level position because of the support columns located centrally in this room (photos. CA-133-1-A-6, A-7).

Although arranged somewhat differently, the consoles in the SLC-3W Control Room (Room 105; fig. 5.22) are functionally and technically equivalent to those in the SLC-3E Control Room with a few minor exceptions. One exception is the gauges on the LAP that show pressures in the liquid oxygen and fuel tanks on the vehicle and in the liquid nitrogen pressurizing system (photo. CA-133-1-A-24). These somewhat redundant gauges were never installed in the SLC-3E LAP.[7] The SLC-3W Facilities panel lacks the hold down/release system controls present on this panel in the east pad control room because SLC-3W remains in the Atlas E/F configuration; its launcher does not have a hold-down system. The SLC-3W Battery Clock panel has gauges for only two batteries instead of four because the destruct signal receivers on vehicles launched from SLC-3W are powered by the main battery instead of by separate batteries. A final, minor difference between the consoles in the SLC-3E and SLC-3W control rooms is that many communications panels in the SLC-3W Control Room have rotary dials instead of touch-tone key pads (photos. CA-133-1-A-15, A-18, A-20, A-25).

The SLC-3W Control Room contains several unique pieces of equipment. The most notable is the bunker periscope located on the north wall near the escape tunnel (fig. 5.22-"P"; photos. CA-133-1-A-29 through A-32). Bunker periscopes were originally designed and manufactured by Kollmorgen Optical Corporation in Northampton, Massachusetts, specifically for use at space launch complexes at Cape Canaveral (fig. 5.25). The "Type 2, Model 523" bunker periscope in the SLC-3W Control Room was installed new in 1959. The periscope offers two magnifications: 1.5x with a field of view of 32 degrees, and 6x with a field of view of 8 degrees. The right handle in the pair of handles visible in photograph CA-133-1-A-30 selects the power of magnification; the left handle elevates the line of sight. The periscope can be rotated through a full 360 degrees to view either launch pad in the event of failure of the television cameras or loss of power in the LOB. Shortly after its installation, the bottom of the periscope tube was extended with an approximately 3-foot length of steel tubing wrapped with caution tape as a safety precaution. The periseope has been modified only once since the addition of the lower tubing. In 1991, the periscope was disassembled for cleaning, and two features were added: a Schrader valve for injecting nitrogen gas into the periscope to keep the

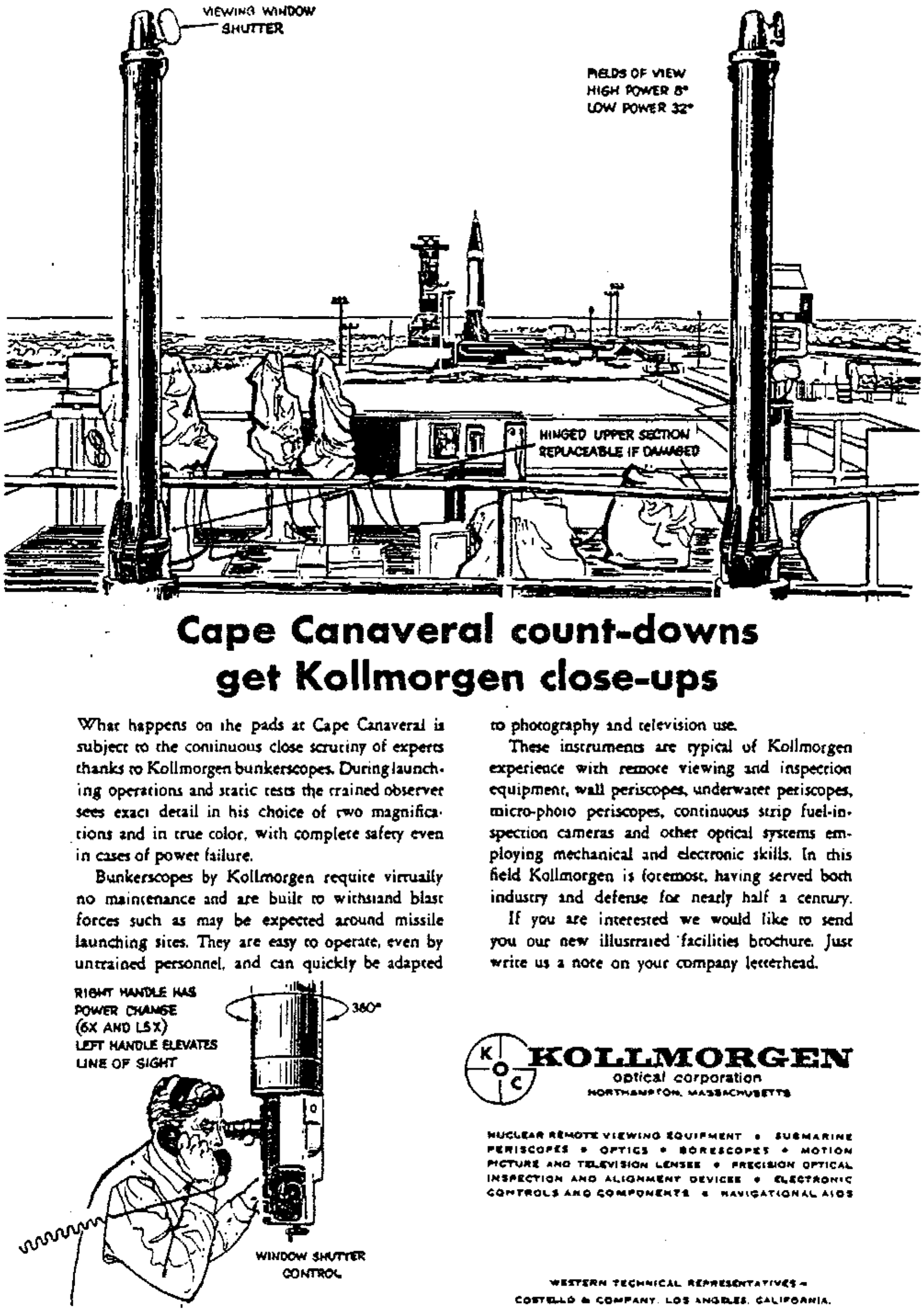


Fig. 5.25. Marketing brochure for Kollmorgen bunker periscopes
(Source: Kollmorgan Optical Corporation, Northampton, Massachusetts)

lenses and prisms dry (photo. CA-133-1-A-29) and a pressure gauge for verifying positive pressure inside the periscope (photo. CA-133-1-A-32) to ensure that moisture and debris are not penetrating the exterior tube.

Another feature unique to the SLC-3W Control Room is the Contel personal computer located in the northwest corner of the room (fig. 5.22-"Q"; photo. CA-133-1-A-19). The computer provides a direct link with weather reports and forecasts provided by the range weather station at North VAFB. The computer system was installed by the Air Force in 1981 to assist in making weather restriction determinations for launches and for other weather-related safety determinations regarding operations on the pads. The computer system is wired to an adjacent chart recorder (manufactured by Brush) that provides a hardcopy record of various weather parameters.

Two other features unique to the SLC-3W Control Room include a conventional, electric, military-time clock mounted on the north wall beneath the monitors (photo. CA-133-1-A-33) and a small lighted box to the west of the clock that indicates when power to various structures is being drawn from a back-up power plant on VAFB rather than from the commercial power supply.

Telemetry Room

The Telemetry Room (Room 106) is located between the control rooms on the street level of the LOB (fig. 5.22; photo. CA-133-1-A-35). Only half of the room is currently in use. It contains instrumentation for receiving and recording radio telemetry signals from the delivery and space vehicles, testing and monitoring propellant utilization, and controlling and monitoring the vehicle's radio guidance system.

Atlas telemetry conveys information about vehicle parameters such as tank pressures, fuel temperatures, battery voltages, etc. via 7-watt, FM, radio-frequency signals transmitted from 4-inch antennae mounted on the lower 20 feet of the vehicle. The radio-frequency signals correspond to voltages registered on sensors on the vehicle. The Atlas telemetry system is a solid-state, modular PAM/FM/FM device. Signal conditioning, commutation, and transmission are electronic. Atlas telemetry transmits measurements of approximately 120 baseline parameters and is capable of carrying up to 78 additional mission-peculiar (i.e., space vehicle) measurements for a total of 198 possible measurements.

The telemetry instrumentation in the LOB is used to record Atlas telemetry during pre-launch tests, countdown, and for approximately the first ninety seconds after launch. Once the vehicle is airborne, the signals are monitored from several test missile and range telemetry stations located outside SLC-3 throughout the range of the vehicle (fig. 5.26). The telemetry for Atlas D launches generated 100-watt signals. The wattage of telemetry signals was reduced

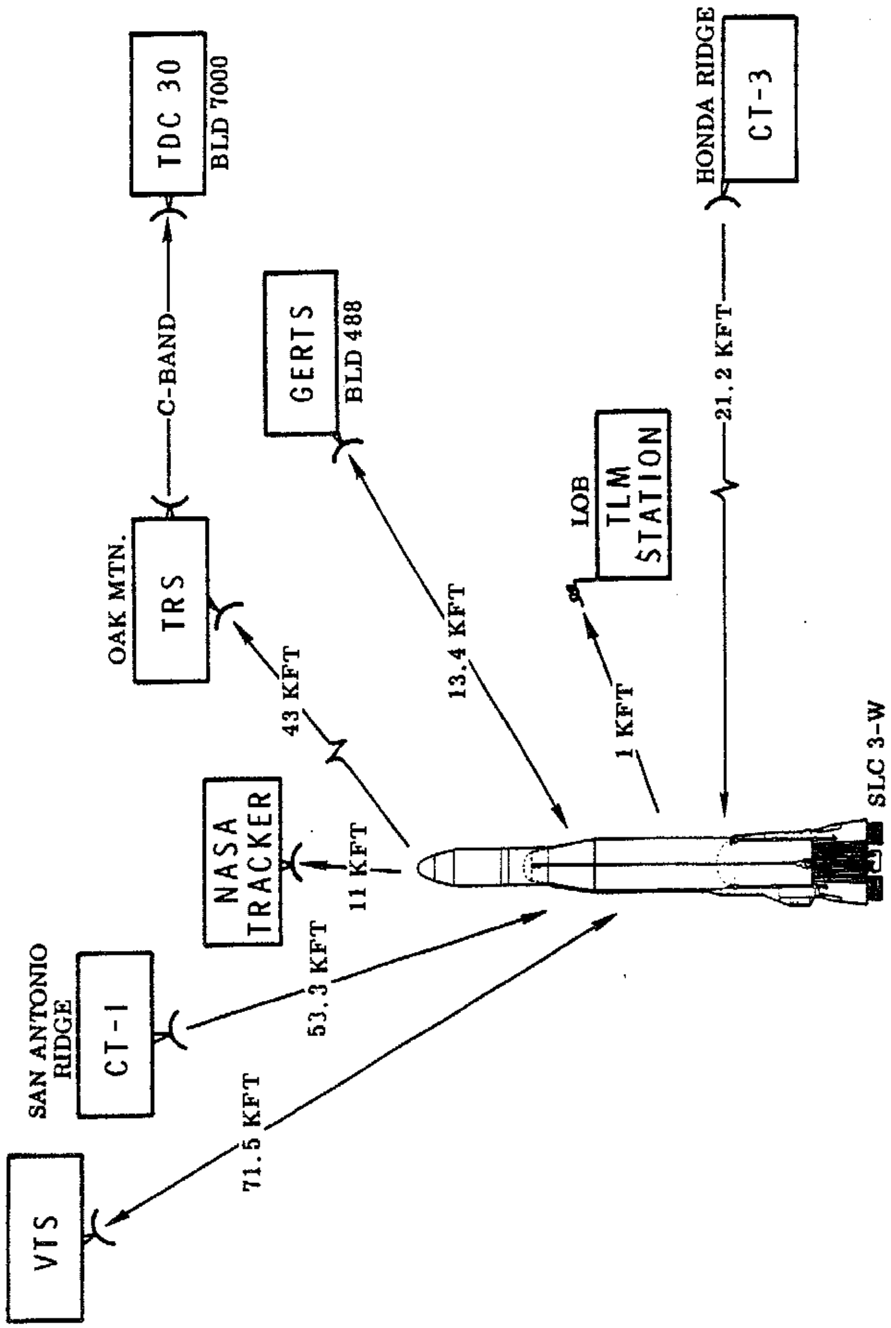


Fig. 5.26. Schematic showing range telemetry stations for tracking launches from SLC-3
(Source: Atlas E/F Orientation, General Dynamics Convair Division, 27 October 1976)

to 7 watts in 1964 because the 100-watt signals exceeded reception requirements and demanded a substantial power supply. The reduction in signal wattage was the result of improvements in the technology of airborne and ground telemetry equipment that came with the Atlas SLV.

The telemetry equipment consists of three bays of electronic instrumentation, a tape recorder, and a pair of computers (photo. CA-133-1-A-35). The three primary instrumentation bays--the RF Console, Demultiplex Bay, and Analog Record Bay (fig. 5.22-"AA, BB, CC," respectively)--constitute the TM-ISE-3 Telemetry Checkout System. The Telemetry Checkout System was acquired new in 1963 for Douglas Aircraft Corporation (now McDonnell Douglas) to support Thor/Delta launches from SLC-3W. It was manufactured by Lear Siegler, Inc., Electronic Instrumentation Division, Anaheim, California. The system was installed in the LOB in 1967. Prior to 1967, telemetry support was furnished from a mobile telemetry trailer that was semi-permanently mounted on a concrete slab located equidistant between PALC-1 (SLC-3) and PALC-2 (SLC-4). It supported both launch sites. At that time, the system served as the primary telemetry system, because the "look angle" of the range telemetry station available then was insufficient to detect the signal prior to lift-off. In 1973, the station was modified extensively to support Atlas E/F launchers from SLC-3W. It has been modified and upgraded several times and has supported all launches from SLC-3 since 1973. The tape recorder, a Honeywell Model Ninety-Six Magnetic Tape System, was installed new in the mid-1980s to replace the original tape recorder. The pair of Loral ADS 100A computers quantize (i.e., convert to a numerical value) the data received via the telemetry signals. The computers were installed new in 1989.

The function of the RF Console (fig. 5.22-"AA"; photo. CA-133-1-A-36) is to select, receive, and distribute radio frequency signals from the delivery vehicle. The three equipment panels on the top of the console are original (photos. CA-133-1-A-37 through A-39) and unmodified; however, they are no longer used, and the Singer Metrics spectrum analyzer and oscilloscope in the center panel do not work. The two panels on the lower left of the console contain original Nems Clarke receivers and Avantek multicouplers (photo. CA-133-1-A-40). The two panels on the lower right of the console are the original Singer Metrics power supply for the RF Console and an AM/FM radio that has no function in the Telemetry Checkout System.

The vehicle's radio frequency signals are sent from the receivers in the RF console to the Demultiplex Bay (fig. 5.22-"BB"; photo. CA-133-1-A-42), where they are separated into individual measurements that are recorded directly onto magnetic tape via the Honeywell tape recorder (fig. 5.22-"BB-7", photo. CA-133-1-A-35) and processed for analog recording. The demultiplexor (fig. 5.22-"BB-3"; photo. CA-133-1-A-45) separates the radio frequencies. It has twenty channels: eighteen carry one measurement each; two are commutated and carry ninety measurements each via frequency modulations. An original patchboard adjacent to the demultiplexor (fig. 5.22-"BB-4"; photo. CA-133-1-A-42) is used to select which channels will be recorded on tape and displayed on the oscilloscopes. The panel to the immediate left of the demultiplexor contains a Hewlett Packard function generator and oscilloscope (fig. 5.22-"BB-2"; photo. CA-133-1-A-44) that are used to calibrate the other instruments in the bay. The controls on the function generator are used to select the frequency and amplitude of the signals it produces. The function generator can produce square, saw tooth, sine, and triangle waves. The panel at the left (east) end is a control and monitoring system for the Demultiplex Bay's power supply (fig. 5.22-"BB-1"; photo. CA-133-1-A-43). The two vacuum-tube oscilloscopes at the right (west) end of the bay (fig. 5.22-"BB-5,6"; photos. CA-133-1-A-46 through A-48) are original and have not been replaced with more recent technology because General Dynamics has been unable to find new models that provide the same resolution. The ITT Federal Electric instrumentation underneath the oscilloscopes controls the volts per division, intensity, focus, and position of the display.

The demultiplexed, decommutated telemetry information is recorded at the Analog Record Bay (fig. 5.22-"CC"; photo CA-133-1-A-49). The bay is equipped with two kinds of recorders. The information displayed on the oscilloscopes is recorded on oscillographs, which are photosensitive chart recorders, located in the two panels at the left (north) end of the bay (fig. 5.22-"CC-1"; photo. CA-133-1-A-50). Selected channels are recorded on ink-type chart recorders in the other four panels of this bay. Each chart recorder can record up to eight channels. The patchboard visible in photograph CA-133-1-A-50 is used to select which channels will be recorded on which chart recorder. All chart recorders were installed new in 1989. The cathode ray tubes located above the chart recorders in the center two panels display quantized data from selected channels (fig. 5.22-"CC-2"). The telemetry data are quantized by the two Loral-ADS 100A computers located against the north wall of the telemetry room (fig. 5.22-"DD"; photo. CA-133-1-A-51).

The propellant utilization monitoring and radio guidance system instrumentation are located on the south wall of the Telemetry Room, immediately behind the Demultiplex Bay (fig. 5.22-"EE, FF"; photo. CA-133-1-A-52). Each system comprises duplicate equipment for the east and west pads. The equipment for the west pad was installed new in 1971, and the equipment for the east pad was installed new in 1974, concurrently with each pad's conversion to the E/F configuration.

Atlas vehicles are equipped with an airborne propellant utilization control unit (PUCU) that monitors and regulates the flow rates of the two propellants (i.e., RP-1 and liquid oxygen) to maximize thrust energy achieved from the sustainer engine and minimize residual propellant when the sustainer engine is cutoff. The digital system samples and adjusts the flow rates of the propellants at seven discrete points during flight via seven level sensors located along the longitudinal axis of each propellant tank. The sensors are paired so that a difference in the time of uncovery of a sensor in one propellant tank and its mate in the other is directly proportional to the error in the ratio of propellant usage. The time difference is measured by a small solid-state computer and converted to a DC voltage. The DC voltage is applied via a differential amplifier to a hydraulic control unit that directly controls the positions of a series of propellant utilization valves to adjust the usage ratio.[8]

The Honeywell Propellant Utilization System Test Set (PUSTS; Photo. CA-133-1-A-53) located in the LOB is used during Atlas E/F processing to adjust the propellant utilization valves to the required mixture ratio and check components and operations of the PUCU. The components of the PUSTS are a Lamda power supply, a stimulator with switches for each of the seven level sensors (the panel has eight switches because the PUCU is capable of monitoring at eight discrete points; however, only seven are used), a Hewlett Packard timer for synchronizing measurements, a Fluk voltmeter for registering voltage changes at the sensors, and a control panel for adjusting components of the system and setting up tests. The results of PUSTS tests are recorded on the Gould chart recorders adjacent to the PUSTS consoles.

The blank console visible in photograph CA-133-1-B-143 once contained the propellant utilization test system for the Atlas H. The Atlas H propellant utilization control system used mercury manometers in the center of the propellant tanks to determine propellant levels on the basis of pressure differences rather than the microchip sensors used in the Atlas E/F.

Atlas vehicles are equipped with a General Electric Radio Tracking System. The airborne equipment consists of a ModIIIG pulse beacon and decoder. The beacon emits a C-band pulse in response to a fourteen-pulse, X-band message from a ground tracking station located outside of SLC-3. The response pulse transmits information regarding the trajectory and flight attitude (i.e, pitch, yaw) of the booster. During prelaunch testing, the response pulse is monitored by the General Electric Airborne Beacon Equipment Test Set (ABETS) located in the LOB (fig. 5.22-"FF"; photo. CA-133-1-A-54). Associated equipment includes an elapsed-time counter for recording the time between response pulses and a Gould chart recorder.

Autopilot Room

Atlas vehicles are equipped with an airborne autopilot system that uses gyroscopes to control the flight attitude (i.e., adjust gimballing of engines to control roll, pitch, and yaw) of the delivery vehicle and provides discrete commands to the delivery vehicle and payload. Such commands include engine cutoff signals, fairing separation signals, and pyrotechnic currents for initiating booster separation. The autopilot system is programmed, tested prior to launch, and monitored from the Autopilot Room in the LOB.[9]

The Autopilot Room, located in the northeast corner of the lower level (fig. 5.23), contains three kinds of equipment: autopilot programming and monitoring equipment; Honeywell optical and Gould ink-type chart recorders, and an IBM autopilot computer (photos. CA-133-1-A-85 through A-87). The autopilot programming and monitoring equipment currently in the room dates from the early 1960s and was designed by General Dynamics and manufactured by Astronautics. The equipment was transferred to SLC-3 from Cape Canaveral in 1975 to support Atlas E/F launches from SLC-3E. Duplicate equipment to support E/F launches from SLC-3W had been transferred to SLC-3 in 1971 but was replaced with the IBM personal computer in 1989.[10]

The old autopilot equipment was replaced because the tape punch and reader used to program and test the autopilot system were obsolete, and replacement parts could not be obtained. The top panel of the cabinet labeled Location 25 (fig. 5.23-"B"; photo. CA-133-1-A-88) contains gyroscope monitors used to verify proper gimballing and position of engines. The middle panel is the tape punch used to prepare simulation programs for testing the autopilot system, and the bottom panel is the calibration meter for the gyroscope recorder. The cabinet labeled Location 26 (fig. 5.23-"C"; photo. CA-133-1-A-89) contains the controls used to program a test simulation and the tape reader. The cabinet labeled Location 24 (fig. 5.23-"D"; photo. CA-133-1-A-90) contains the controls for transmitting the program to the vehicle. The IBM computer tests and monitors the gimballing of engines and the proper operation of gyroscopes on the Atlas using software developed by General Dynamics.

The chart recorders in the northeast corner of the room (fig. 5.23) support SLC-3W and record the positions of the gyroscopes and engines at prescribed times. The chart recorders in the southeast corner supported SLC-3E and are no longer used. The optical chart recorder (photo. CA-133-1-A-94) or "visicorder," records fairing separation signals. Thirty-six signals can be monitored on the optical chart recorder because it has eighteen channels, each of which records two signals. Four eight-channel, ink-type recorders would be required to record all of the thirty-six fairing separation signals. Several air-conditioning ducts located in the ceiling in the northwest corner of the room (photo. CA-133-1-A-91), immediately above the current position of the autopilot programming and monitoring equipment, were part of an air-conditioning system that cooled vacuum-tube chart recorders used by Lockheed in the early 1970s.[11]

The Goldstar personal computer (photo. CA-133-1-A-92) adjacent to the chart recorders in the northeast corner of the room is a weather monitor connected to the weather monitoring system in the SLC-3W Control Room.

Landline Instrumentation Room and Cable Tunnels

The Landline Instrumentation Room is located in the northwest corner of the lower level of the LOB (fig. 5.23; photos. CA-133-1-A-95, A-96). It contains patchboards, control circuits, and analog recorders for the landline instrumentation systems for each pad; all other components of the landline instrumentation systems are located in the respective LSBs. The components of the systems are connected by long cables emanating from each LSB (fig. 5.21) and terminating at the LOB via the cable tunnel (fig. 5.23; photo. CA-133-1-A-105). The landline instrumentation system acquires a wide variety of data from the Atlas, payload, and ground equipment during prelaunch testing and countdown. During countdown, recordings of the data are compared to standard error bands for the respective measurements to identify any deviations that may require interrupting a launch sequence.

The nineteen Esterline Angus, ink-type chart recorders located in two rows along the north wall of the room (fig. 5.23-"H"; photos. CA-133-1-A-97, A-101) were installed new in 1982, replacing Daystrum, vacuum-tube, ink-type recorders that had been installed new in 1971. The original recorders, installed new in 1959 and used continuously until 1971, were Brush and Sanborn vacuum-tube models that traced on thermal paper with a hot stylus. The Esterline Angus recorders support both pads and are configured for a particular pad using the patchboard located in the southeast quadrant of the room (fig. 5.23-"I"; photos. CA-133-1-A-95, A-100). Each recorder accommodates two channels. The Esterline Angus recorders are equipped with controls for adjusting the speed of the trace to retain recording resolution during the commit sequence and the first few seconds after launch, when data are collected rapidly. Three additional Esterline Angus recorders located at the west end of the front row of cabinets on the south wall (fig. 5.23; photos. CA-133-1-A-95, A-98) record autopilot and electrical data for either pad. The adjacent patchboard was installed in 1971 and is used to select the pad and measurements to be recorded on the autopilot/electrical recorders (fig. 5.23-"J").

A Granetz computer system located at the east end of the room near the entrance (fig. 5.23-"K"; photo CA-133-1-A-102) was installed in 1985. The Granetz maintains a digital record of the sequence of events during prelaunch testing and countdown. Associated equipment includes two General Electric printers that provide a hard copy of the information recorded by the Granetz.

The first of two rows of equipment cabinets near the south wall of the room is known as the Instrument System Conditioning System. The sixteen Gould ink-type chart recorders (fig. 5.23-"L"; photo. CA-133-1-A-97) were installed in the mid 1980s. Each records eight channels and is equipped with signal conditioners and amplifiers for each channel. Two Honeywell optical chart recorders (fig. 5.23-"A"; photo. CA-133-1-A-97) equipped with mercury arc lamps record data from the hold down/release system on the SLC-3E launcher and data related to significant events in launches from either pad, such as commit start, engine start, engine tank pressures, and engine cutoffs. These data are recorded on optical systems because they are faster and provide better resolution of launch-critical measurements than the ink-type recorders. The controls in the cabinet labeled U313 (fig. 5.23-"M"; photo. CA-133-1-A-99) were used to calibrate the instruments that collect data about the payload air-conditioning system on SLC-3E. The controls in the cabinet labeled U305 (fig. 5.23-"N") are used to calibrate the same instruments at SLC-3W.

Two rows of cable distribution units line the west wall, near the cable tunnel. The row closest to the wall is for west pad cables; the front row was formerly for east pad cabling but is no longer used. Each row contains a patchboard for distributing signals to the appropriate landline instrumentation. The patchboard for SLC-3E (photo. CA-133-1-A-103) is now used as a back-up for SLC-3W. The floor tiles in the landline instrumentation room are removable for access to the cables located beneath them. Photograph CA-133-1-A-104 shows one tile removed to expose the cables.

Communications Room

All communications systems for SLC-3 are supported by Dynamic Sciences, Inc. (Dynamic Sciences). In 1992, Dynamic Sciences won the contract previously held by Quintron. In 1972, Quintron Systems bought the support contract and original communications equipment from ITT Federal Electric, the original manufacturer and communications support contractor. Despite several changes in the eontracting company, several of the SLC-3 communications technicians have worked there for more than twenty years, and at least one has been there since 1959.

The Communications Room is located on the lower level of the LOB on the west side, directly below the Telemetry Room. The equipment in the communications room is known as modular elect solid state aerospace ground equipment (MESSAGE). The equipment bank closest to the west wall contains all the wiring for external (outside Vandenberg) and South VAFB communications, including the twenty-channel SLC-3 network (fig. 5.23-"R").

The next bank of cabinets, moving east into the room, contains the controls for voice communications stations throughout the pad (fig. 5.23-"S"). Prior to 1975, these controls were mechanical relays. The SLC-3W voice communications system was upgraded to printed circuit boards in 1974; the SLC-3E system was similarly upgraded in 1976. This second bank of cabinets also contains amplifiers for the communications signals; a TEAC tape recorder for preparing simulated-flight test signals to be relayed throughout the LOB; and the vehicle lift-off system, which sounds a tone when the delivery vehicle rises one inch off the pad and relays the signal for activating the high-speed still cameras.

The third bank of cabinets (fig. 5.23-"T") contains fuse panels and the clock master. The clock master controls all countdown, hold, and Greenwich mean time clocks on SLC-3. The third bank also contains a power supply and static frequency converter manufactured by Lorain Products Corporation of Lorain, Ohio. These are the only original pieces of equipment remaining in the communications room.

The fourth bank of cabinets (fig. 5.23-"U"; photo. CA-133-1-A-106) contains a DMS100 computer telephone system manufactured by Northern Telecom. This system is an annex of the

North VAFB telephone system. It was installed in 1983 to ensure that SLC-3 will have uninterrupted communications in the event of failure of the SLC-3 communications network. The system is operated by Air Force personnel. This bank also contains fiber-optic video links manufactured by Mercot. The fiber-optic links were installed in 1990 to allow SLC-4 and North VAFB to monitor video transmissions from SLC-3. This bank of cabinets also contains equipment to record transmissions from the surveillance and operational video cameras located around SLC-3 (photo. CA-133-1-A-107). Also in this bank are the microwave data transmission system transmitters and receivers for each pad. These systems receive delivery vehicle telemetry data, space vehicle telemetry data, and video signals. The original microwave equipment was installed in 1973 and had separate transmitters and receivers. The SLC-3W system was upgraded in 1991, and now has the transmitter and receiver in one box. Both systems were made by Collins Microwave and use a multiplexed signal of four frequencies.

The Communications Room is equipped with two banks of lead-cadmium batteries located along the east and south walls (fig. 5.23-"Q"; photo. CA-133-1-A-108). The batteries provide primary power during a launch and back-up power at other times. Just prior to countdown, the Communications Room is switched to battery power to ensure an uninterrupted supply of power to the SLC-3 communications network at all times during the launch. The batteries are continually recharged from the commercial power supply. The battery system on the east wall was manufactured by Gould; the one on the south wall was manufactured by C&D Batteries, a division of ELTRA Corporation. The batteries on the east wall support the DMS100 computer telephone system; those on the south wall support all the Dynamic Sciences, Inc. communications equipment, including the microwave system. Prior to 1973, the Communications Room used lead-acid batteries. These were replaced with the lead-cadmium variety because of their longer life-span.

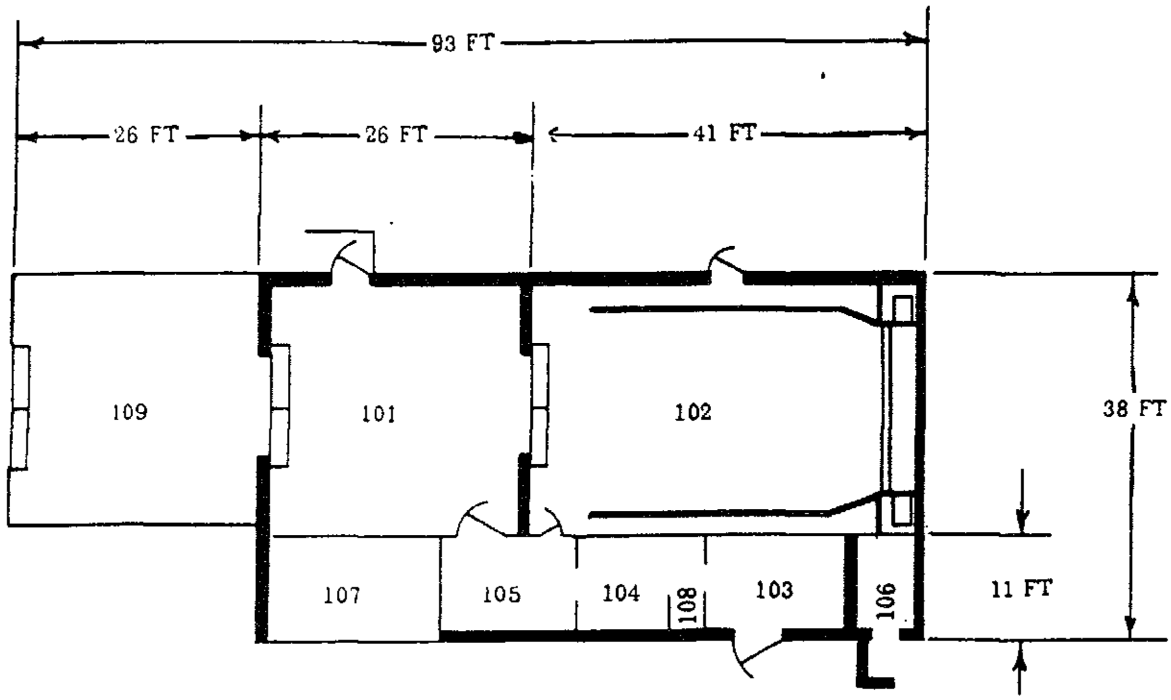
Vehicle Support Building (Bldg. 766)

The Vehicle Support Building (Bldg. 766), located east of SLC-3W (fig. 5.4; photos. CA-133-1-D-1 through D-3), is a 26-foot high, structural steel building with sheet-metal siding. The building is approximately 38 feet wide and 67 feet long (fig. 5.27). The original 26-foot by 27-foot, raised, concrete loading dock (photos. CA-133-1-D-17, D-18) was enclosed to form Room 109 in 1974 (fig. 5.27; photos. CA-133-1-D-4, D-5). Room 106 (Pyrotechnic Storage Room) at the southwest corner of the building is the only exception to the construction design. Explosive bolts that are detonated in flight to separate the halves of the payload fairing are stored in this room. Room 106 is constructed of 8-inch concrete block. A blast panel located in the south wall directs explosive energy away from occupied portions of the building (photo. CA-133-1-D-18). The only entrance to Room 106 is from the outside. A 4-foot by 4-foot, 8-inch thick, "L"- shaped, concrete-block wall provides blast protection for personnel outside the building and on the adjacent road.

In the Vehicle Support Building, the fairing that protects the payload during the first three minutes of flight and the adapters that mate the fairing to the delivery vehicle are assembled and cleaned of foreign objects that might interfere with delicate satellite instrumentation. Cleaning occurs in three main rooms (Rooms 109, 101, 102; fig. 5.27) with 20-foot ceilings. The fairing enters the building through the large double doors on its north face. In the first room, Room 109 (photos. CA-133-1-D-4, D-5), the payload fairing and adapters are cleaned of gross dirt, and final construction of each piece is completed. In the second room (Room 101; photos. CA-133-1-D-8, D-9), the payload fairing and adapters are assembled, explosive bolts are installed, and the assembly is wiped of fine adherent dirt and fingerprints. Final cleaning, cleanliness certification, and assembly take place in the third room (Room 102; photos. CA-133-1-D-10, D-11).

The floors of Rooms 101 and 102 are made of spark resistant concrete. The walls and ceilings of these two rooms are designed to withstand fire for a minimum of one hour. The fire-resistant, metal, sliding doors between Rooms 109 and 101 and between Rooms 101 and 102 are 10 feet wide by 10 feet high. The doors are clad in aluminum to prevent sparks. A 2-foot by 4-foot viewing window in the west wall of Room 102 allows personnel outside the room to view the progress of final cleaning and assembly (photo. CA-133-1-D-17). A 1.5- by 0.25-inch copper grounding bus runs along the perimeter of Rooms 101 and 102 to ground equipment, fairings, and tools (photo. CA-133-1-D-20). Copper-clad, steel, 0.75-inch by 20-foot ground rods are buried throughout the building and around its exterior perimeter to ground the grounding bus, floors, and the steel building structure. All electric lighting and switches in Rooms 101 and 102 are explosion or spark proof. A fire alarm system and a large-capacity, water deluge system (photo. CA-133-1-D-19) provide fire suppression in Rooms 101 and 102. The deluge water is supplied from the water main through a 6-inch pipe rising external to the south wall of the building (photos. CA-133-1-D-17, D-19, D-3).

In 1974, Room 102 was converted to a class 100,000 clean room by installing a floor-to-ceiling, laminar-flow filter near the south wall of the room (photo. CA-133-1-D-10). False partition walls extending 36 feet from the south wall of Room 102 were constructed from floor to ceiling, 18 inches inside the original east and west walls. The spaces between the false walls and the walls of the room form passages for air returning from the clean room (photo. CA-133-1-D-12). Air is drawn into a plenum behind the laminar-flow filter by two large fans and then exhausted through the laminar-flow wall back into Room 102. A floor-to-ceiling prefilter located at the south ends of the passages formed by the false walls removes large particles from the air before it enters the plenum. During a cleaning operation, Room 102 is sealed, and air within the room is recirculated continuously via the laminar-flow filtration system. The air in Room 102 is monitored continuously for particles during fairing cleaning. Air is sampled via an inlet tube mounted 8 feet high on the east false wall. The concentration of airborne particles in the room is measured three times per minute using a Royco Instruments computerized particle counter (photo. CA-133-1-D-13), and readings are averaged to ensure that air in the room



ROOM NO.	USAGE	AREA (SQ. FT.)
101	ASSEMBLY	625
102	TEST (CLEAN ROOM)	1000
103	STORAGE	143
104	TOILET	117
105	SHOWER	110
106	PYRO STORAGE	76
107	MECHANICAL EQUIPMENT ROOM	209
108	JANITOR CLOSET	14
109	RECEIVING AND SHIPPING	610

Fig. 5.27. Vehicle Support Building (Bldg. 766), general arrangement

remains within cleanliness criteria. After final cleaning, the fairing is scanned for remaining particles and fingerprints using ultraviolet scanners manufactured by Ultraviolet Products, Inc. (in use since early 1970s). Once certified clean, the fairing is wrapped in plastic and sealed (photos. CA-133-1-D-14, D-15) to keep it clean during transportation to the MST.

In 1977, the original hoist mounted on a monorail in the ceiling of Room 102 was replaced with a two-ton electric bridge crane (photos. CA-133-1-D-21, D-11). The crane allows almost complete access to all points within the room for moving and manipulating the fairing and adapters during cleaning and assembly. Braces were added to the roof trusses to withstand the additional transverse and lateral loading created by the bridge crane.

Because organic solvents are used in the cleaning process, the ventilation system in Room 101 was improved in 1983. A 2200-cubic foot per minute exhaust fan and a 2500-cubic foot per minute supply fan were installed in the mezzanine area of the building (fig. 5.27) The supply fan draws air from the mezzanine through a sheet-metal chamber containing a 24-inch bag filter. The air is ducted from the mezzanine to a 14-inch diameter flexible hose (photo. CA-133-1-D-8) in Room 101. The hose is split into two 10-inch diameter hoses at its distal end to provide flexibility in locating the fresh air stream. A shed containing a 10-horsepower compressor was added adjacent to Room 106 circa 1984 (fig. 5.27; photo. CA-133-1-D-3).

The west side of the Vehicle Support Building includes the following rooms (fig. 5.27): Room 103 (an office), Room 104 (Personnel Preclean Room), Room 105 (Personnel Clean Room), and Room 107 (Mechanical Equipment Room). These rooms have 10-foot high ceilings. Rooms 104 and 105 provide facilities for cleaning personnel to prepare to enter Room 102 for final cleaning. Preparation includes donning full tyvek suits over street clothing and hair. The mezzanine located above the west rooms contains the air-conditioning system, including a steam generator, air handlers with ducting, and air filtration systems. The steam generator provides steam to the air-conditioning system allowing more precise control of temperature and humidity. The original, air-cooled condenser unit for the air-conditioning system was located on the roof (photo. CA-133-1-D-18). This unit was removed, and an air-conditioning condensing unit was added on the ground level on the north side of the building (photo CA-133-1-D-3); the dates of these changes are unknown. Room 107 houses the water-cooled chiller for the air-conditioning system, a domestic water heater, a space-heat water heater, and a large-capacity vacuum cleaner used in Rooms 101 and 102 during fairing cleaning (photo. CA-133-1-D-19). The only access to the Mechanical Equipment Room is through an exterior door on the north face of the building, west of the doors to Room 109. The only access to the mezzanine is via a steel ladder and hatch in Room 107 (photo. CA-133-1-D-18).

Associated Infrastructure

Technical Support Building (Bldg. 762/762A)

The Technical Support Building (Bldg. 762/762A; formerly Complex Service Building), constructed in 1959, is a single-story, structural-steel framed, sheet-metal sided structure 73 feet long by 36 feet wide (photos. CA-133-1-E-1, E-4, E-2). The building functioned as a communications center and office space for the operating contractor for the complex (General Dynamics) and Air Force personnel. The partition walls, with the exception of the Boiler Room (Room 101) and the restroom facility (Room 102), are constructed of standard 2-inch by 4-inch wood studding covered with gypsum board. The walls of Rooms 101 and 102 are constructed of concrete block. Originally, Room 107 was used as a maintenance facility for small aerospace ground equipment. The Boiler Room contains a fuel oil fired, hot water boiler for building heat, an electric water heater for domestic use, and an electric motor operated air compressor to service the Facility Maintenance Room. A 275-gallon fuel oil tank was located outside at the northeast corner of the building.

During 1965, the Technical Support Building was extended 18 feet by adding a new section, identical to the original building in design, to the south face (photo. CA-133-1-E-5). In addition, the entire building was converted to office space. The Facility Maintenance Room (Room 107) was divided into two separate rooms by wood stud partitions. All rooms were then renumbered.

In 1976, Building 1776 at ABRES A was dismantled and relocated to SLC-3 to provide additional office space for the operating contractor (General Dynamics). It was located adjacent to Building 762 and attached via a 7-foot by 14-foot enclosed entry way (photos. CA-133-1-E-3, E-7, E-6). Building 1776 was redesignated Building 762-A. Building 762-A is of identical design as Building 762; namely, structural steel frame clad with sheet metal. Building 762-A, however, is considerably larger, measuring 120 feet long by 60 feet wide (photos. CA-133-1-E-3, E-7, E-6). All permanent interior partitions are constructed of gypsum board over 2-inch by 4-inch, steel studding. Lighting is provided predominantly by standard two- or four-tube fluorescent fixtures mounted in the suspended acoustical board ceiling (photos. CA-133-1-E-7, E-8). Standard-110 volt, duplex power receptacles are provided throughout all offices, and heat is provided by electrical baseboard heaters (photo. CA-133-1-E-8).

SLC-3 Air Force Building (Bldg. 761)

The SLC-3 Air Force Building (Bldg. 761; formerly *Samos* Technical Support Building), constructed in 1959, was originally used by the operating contractor for office space, minor maintenance, and storing aerospace ground equipment. It is a structural-steel framed, sheet-metal sided building with interior partitions constructed of 2-inch by 4-inch wood studs overlain with gypsum board (photos. CA-133-1-F-1 through F-4). Lighting was provided by standard two- and four-tube fluorescent lights hung from the ceiling. Duplex electrical receptacles were provided throughout the building. The building was entirely converted to office space in 1976 for Air Force personnel when Building 762A was added to the Technical Support Building. General Dynamics relocated its personnel into the expanded Technical Support Buildings. The only modifications made to the building were modernization of lighting systems, replacement and addition of acoustical board ceilings, the addition of carpeting, and the conversion of Rooms 124, 125, and 126 into a catered military dining facility. Currently, the SLC-3 Air Force Building houses members of the 2nd Space Launch Squadron.

Traffic Check Houses (Bldgs. 759, 760, and 764)

Three identical traffic check houses (Bldgs. 759, 760, and 764) were constructed in 1959 along the main access road to the complex (Bldg. 760), the access road to SLC-3E (Bldg. 759), and the access road to SLC-3W (Bldg. 764) (fig. 5.1; photos. CA-133-1-15, CA-133-1-H-1). The traffic check houses were manned by Air Force Security personnel to ensure that only authorized personnel and vehicles obtained entry to the complex and to each launch pad. Each traffic check house is a structural-steel framed, sheet-metal sided structure, 12 feet long and 4 feet wide (photos. CA-133-1-H-1). Sliding, hollow-metal doors on the 12-foot sides provide through access if necessary. Large windows (4 feet 1 inch by 3 feet 8 inches) on all four sides and smaller windows on the sliding glass doors provide excellent visibility. The roof overhangs the structure by 2 feet on all sides, providing some weather protection and attachment points for the floodlights, horn, and Complex Safety warning lights. Building 759 is the only original traffic check house remaining on SLC-3.

Meteorological Tower and Shed (Bldg. 756)

An open-framed meteorological tower approximately 60 feet tall, located centrally between the pads, measures wind speed and direction for SLC-3 (fig. 5.4; photo. CA-133-1-G-4, G-5). Anemometers and wind direction indicators are mounted at 12 feet and 54 feet on the tower. The Meteorological Shed (Bldg. 756) located immediately southeast of the tower, is a 5-feet 4-inch square, corrugated sheet-metal building that houses computer equipment for recording and transmitting the wind data (fig. 5.4; photos. CA-133-1-G-1 through G-3). The shed is 8 feet 4 inches tall and is equipped with an air conditioner to maintain temperature and humidity within required operating conditions for the equipment during the summer. The tower replaced a similar wind monitoring station formerly located on the roof of Building 763; however, the date of construction of the meteorological tower and shed are unknown.

Sewage Treatment Plant (Bldg. 769)

The sewage treatment plant (STP; Bldg. 769), which was constructed in 1959 on the northeast edge of SLC-3, is an activated-sludge, biological treatment unit with an aeration tank and a secondary settling tank. The entire treatment plant is buried in the ground with grade approximately 6 inches below the top of the STP (photo. CA-133-1-I-1). The aeration tank has a 7,500-gallon capacity and is aerated by a 2-horsepower blower through a swing-arm air diffuser. A manually operated hoist raises the swing-arm aerator for maintenance. Sewage enters the aeration tank through an 8-inch bar screen; any particles not exiting the bar screen are macerated by the 0.25-horsepower comminutor. Overflow from the aeration tank enters at the top of the 1,500-gallon capacity conical shaped settling tank where the activated sludge floc is settled out. Overflow from the settling tank is discharged to a drainage ditch. The settled activated sludge is recirculated to the aeration tank through an air lift.

***GPS* Azimuth Alignment Station (Bldg. 775)**

An azimuth alignment system was constructed at SLC-3W in 1975 to support *GPS* payloads (photos. CA-133-1-N-1, N-2). The Azimuth Alignment Station is a structural- steel framed, sheet-metal sided building set onto a 4-inch concrete slab. A 2-foot by 6-foot by 8-inch hinged window panel is set into the north face facing SLC-3W. A hollow metal door is located on the west face both for personnel access. A 3-foot isolation bench set on pedestals occupies most of the interior of the building. This isolation bench prevents vibrations caused by nearby vehicles and other activities from affecting the alignment procedures. A monolith, used in the alignment process, is located approximately 7 feet from the west face of the building in the center of the isolation block (photo. CA-133-1-N-2).

Entry Control Point (Bldg. 768)

The Entry Control Point (Bldg. 768; formerly Gate House) was constructed in 1976 to control access to the LOB and SLC-3W. The facility included three new electrically operated, roll-away gates, and new security fencing to tie the roll-away gates and the building to the security fence (photos. CA-133-1-J-1, J-3, J-5). The Entry Control Point is a 15-foot-square structure constructed of 8-inch concrete block. Large sliding glass windows allow security personnel an excellent view in all directions. Two standard steel-framed glass doors provide access to the building. The east entrance is from the nonsecure area, and the west entrance is from the secured area. Normally, the entrances are kept locked, and only security personnel are allowed to enter. A latrine is located inside the structure in the southeast corner. The interior is sparten with a bookcase to hold appliances and a counter for security logbooks (photo. CA-133-1-J-2). The controls for the electrically operated gates are located on the wall adjacent to the counter. The new fence is identical to the existing security fence. It consists of 9-gauge, 2-inch chain-link mesh, 6 feet high, and topped with three strands of barbed wire angled 45 degrees outward from the fence (photos. CA-133-1-J-1, J-6). Support posts embedded in concrete footings are located every 10 feet along the fence line. The three gates are operated via chain drives, powered by 3/4- or 1-horsepower electric motors (photo. CA-133-1-J-5). The gates are constructed of the same chain-link material as the security fence. A 3-foot wide personnel access gate equipped with an electronic lock is located on the northwest corner of the building. The personnel access gate is unlocked remotely by the security guard in the Entry Control Point after verifying an individual's entry authorization.

Storage Sheds (Bldgs. 776 and 773)

In 1976, two identical equipment storage sheds were added to the complex. Building 776, just north of SLC-3E (photos. CA-133-1-L-1, L-2, L-4), is a structural steel framed, sheet-metal sided structure 42-feet long and 16-feet wide set on a 4-inch concrete slab (photo. CA-133-1-L-3). A 10-foot 6-inch metal roll-up door and a 3-foot personnel access door are located on the west face. A 50-foot by 100-foot parking area adjacent to Building 776, and a road leading to the 757 Pyrotechnic Shed (Bldg. 757) were added at the same time (photo. CA-133-1-L-4). A macadam access road to motion picture camera station "A" at SLC-3E was also added. An equipment storage building identical to Building 776 was added at SLC-3W near the Sewage Treatment Plant (photos. CA-133-1-K-1, K-2). The only difference was that the building was salvaged from ABRES-A and renumbered Building 773.

Pyrotechnic Shed (Bldg. 757)

The Pyrotechnic Shed (Bldg. 757) was built in 1976 to provide an isolated location to safely test and store pyrotechnic devices used to separate the delivery and space vehicles and the halves of the payload fairing. The building is a concrete block structure 20-feet 8-inches long and 17-feet 4-inches wide, set on a 4-inch thick concrete slab (photos. CA-133-1-M-1 through M-3, M-6). The Pyrotechnic Shed is divided into four rooms; the only access to each room is from the outside through a 3-foot 4-inch wide aluminum door. Two small storage rooms, one for hypergolic fuel and the other for the pyrotechnic devices, are located on the east side of the building.

The door of the test cell (photo. CA-133-1-M-4) on the south face of the building incorporates a 1-inch thick glass window to the personnel room (photo. CA-133-1-M-5). Whenever a device is tested, an observer is located in the personnel room to provide assistance in case of an accident. The observer and tester communicate through a 3-inch conduit passing through the dividing wall. Warning signs are placed in holders on the south and west faces of the building, and a warning light is activated whenever pyrotechnic tests are conducted.

Security Fence

A 6-foot high security fence of 9-gauge, 2-inch chain-link mesh, topped with three strands of barbed wire angled 45 degrees outward from the fence completely encloses the complex (photos. CA-133-1-J-1, J-6, CA-133-1-15). Support posts embedded in concrete footings are located at 10 foot intervals along the fence line. Double swing gates approximately 40-feet wide are located at the main entrance and at each access road to the launch pads (photo. CA-133-1-A-15).

1. Paul van Alstine. Personal conversation with the author on 17 March 17 1993

2. Ibid.

3. Ibid.

4. Jeff Geiger, Historian, Thirtieth Space Wing, Vandenberg Air Force Base, "Historical Notes."

5. Paul van Alstine, General Dynamics Space Systems Division, personal communication with author, December 3, 1992.

6. M. Spence, General Dynamics Space Systems Division, personal communication with author, January 13, 1993.

7. P. van Alstine, personal communication, January 13, 1993.

8. General Dynamics, Convair Division, "Atlas E/F Orientation," Vandenberg Air Force Base, October 27, 1976.

9. General Dynamics, Convair Division, "Atlas F Orientation for NASA-LeRC," January 18, 1977.

10. Bernie Slot, General Dynamics Space Systems Division, personal communication with author, December 3, 1992.

11. B. Slot, personal communication, January 14, 1993.

CHAPTER 6

EFFECTS OF PLANNED MODIFICATIONS OF SLC-3

The USAF needs to place several medium-weight payloads in polar or near-polar orbits beginning in 1996. VAFB is the only developed site in the continental United States that can launch satellites into polar orbit without crossing over populated areas, but it currently does not have the capability to launch medium-weight payloads. The USAF plans to achieve this capability by renovating the Atlas launch pad at SLC-3E to accommodate the Atlas II family of space delivery vehicles. Alternatives to renovating SLC-3E were considered, including using other launch vehicles or other launch pads; however, all alternatives were rejected for schedule, cost, technical, or environmental reasons.

SLC-3E is one of three Atlas launch pads with A-frame MSTs (SLC-3W and ABRES-A are the other two) and one of two with retractable umbilical masts (SLC-3W is the only other); therefore, SLC-3E contributes significantly to the integrity and historic significance of the whole of Space Launch Complex 3 at North VAFB. The physical integrity of SLC-3 as a whole, as well as its individual components, will be significantly affected by the proposed modifications. Figure 6.1 illustrates the major changes planned for SLC-3. These alterations include modernizing the LOB (Bldg. 763); replacing the original, A-frame MST at SLC-3E; replacing the original SLC-3E rail system; reorienting the SLC-3E deluge channel; and adding several support buildings. Clearly, SLC-3E will be most affected by the planned modifications. No buildings associated with SLC-3W will be modified or replaced, and the demolition and reconstruction at SLC-3E will have no direct effects on SLC-3W. Indirectly, however, the changes proposed at SLC-3E, the addition of new buildings throughout SLC-3, and the demolition of several structures will affect the visual and historical integrity of SLC-3. The relative appearance and setting of the site will be altered, and the symmetry between the east and west pads will be destroyed. Detailed descriptions of the modifications planned for SLC-3E, the LOB (Bldg. 763), and associated infrastructure throughout the complex follow.

SLC-3E

The MST, umbilical mast, rail system, flame bucket and deluge channel, and the LSB (Bldg. 751) are integral parts of SLC-3E that will be modified. Figure 6.2 illustrates the major modifications planned for the SLC-3E MST and launch pad. The existing MST and umbilical mast will be demolished and replaced with a new MST and umbilical tower. The tallest Atlas II vehicle, the Atlas IIAS, is much taller than the Atlas H vehicle for which the pad is currently configured. All Atlas Hs and other vehicles previously launched from SLC-3E used payload fairings of 7-foot diameter or less, but some Atlas IIAS payloads may require 14-foot diameter fairings. To accommodate larger vehicles and larger payload fairings, the existing A-frame

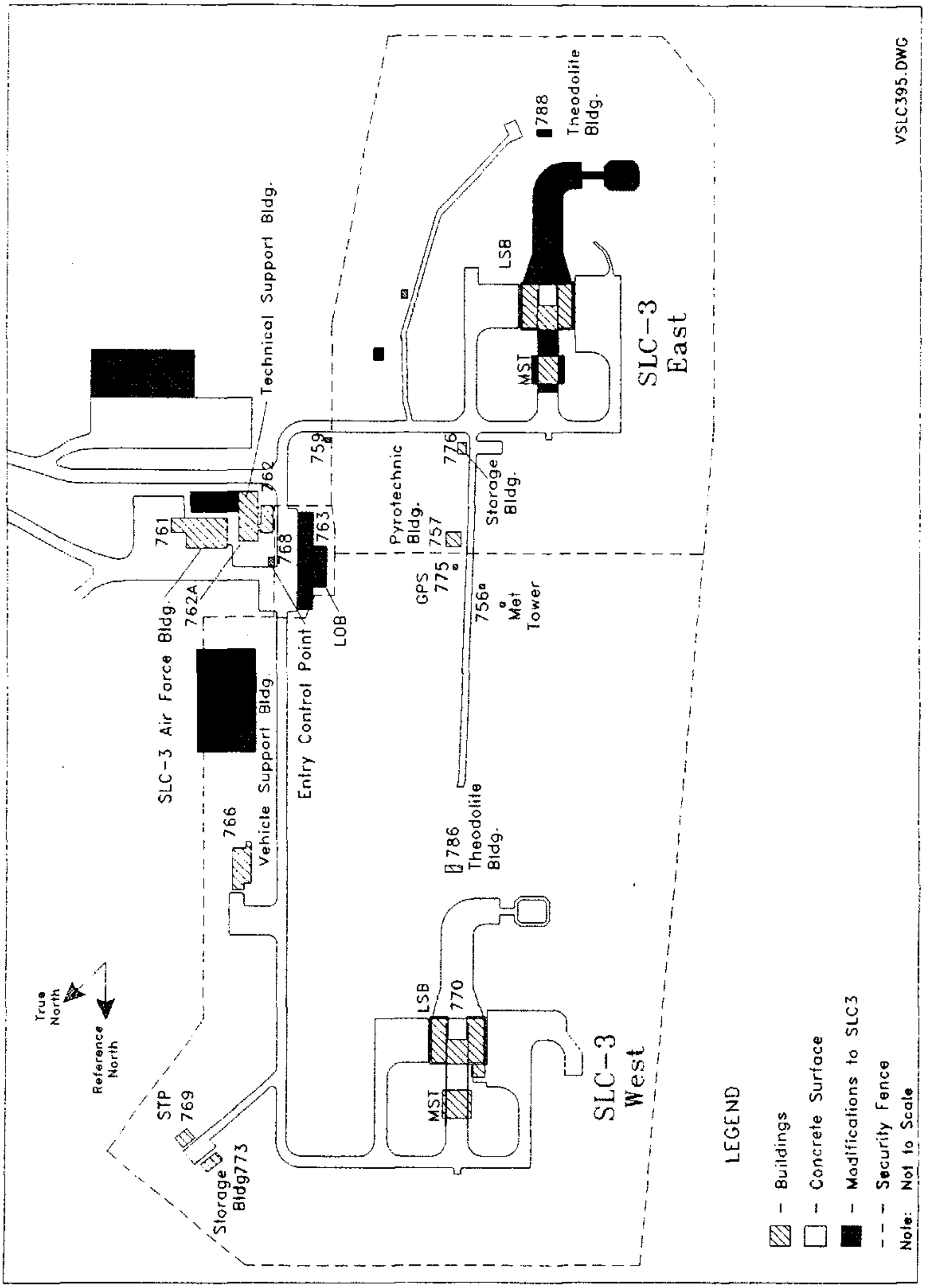


Figure 6.1. Schematic showing planned modifications of SLC-3

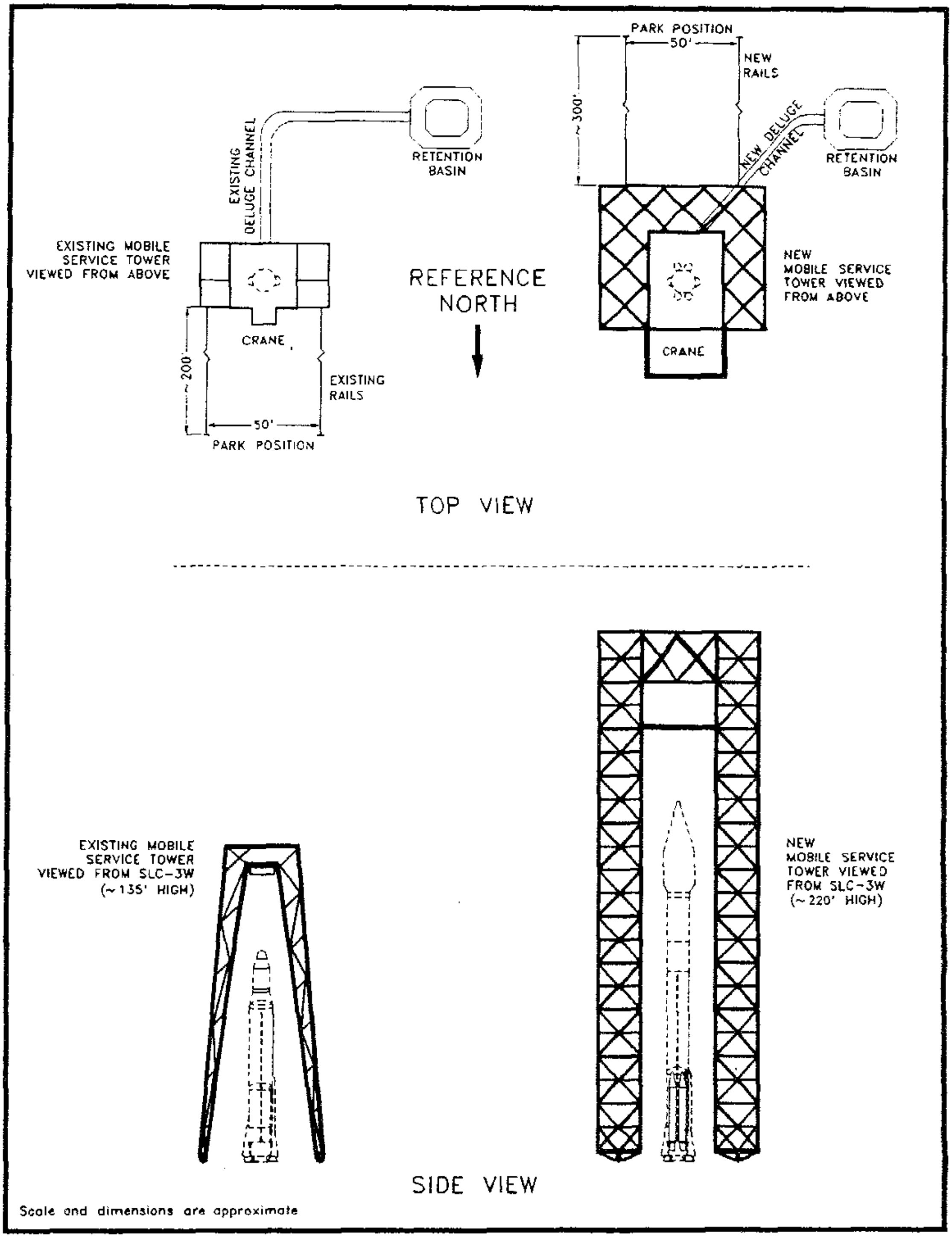


Figure 6.2. Comparison of existing SLC-3E Mobile Service Tower (MST) and C-Frame MST

MST will be replaced with a larger, C-frame MST. The existing umbilical mast retracts into a concrete trench in the surface of the launch deck. The umbilical mast will be dismantled and replaced with a fixed umbilical tower; the trench will be capped with reinforced concrete. The new tower will be a 170-foot, steel structure with a 10-foot by 20-foot base.

The existing rail system for moving the MST will be replaced. The existing system permits the MST to move only north (toward SLC-3W) from its service position to its parked position. The new SLC-3E MST will move south from its service position to its parked position. The existing concrete-lined deluge channel linking the flame bucket and the retention basin will be reconfigured to accommodate the foundation for the new MST rail system (fig. 6.2). The flame bucket and deluge channel will be oriented to carry deluge water directly toward the retention basin. The flame bucket will remain intact but will be extended to deflect vehicle exhaust southwest, directly toward the retention basin, rather than south as it does now.

A theodolite shelter (Bldg. 788) will be removed because its current location will be part of the new rail system.

Launch Services Building (Bldg. 751)

The SLC-3E LSB (Bldg. 751) is the reinforced concrete structure located below the SLC-3E launch deck. The LSB houses payload and vehicle instrumentation, pressurization and checkout units, hydraulic controls for the umbilical mast, and electrical supply and back-up power systems. Also associated with the LSB are the fuel apron on the west side of the launch deck and the oxidizer apron on the east side of the launch deck. Planned modifications of the LSB include renovating the heating, ventilating, and air-conditioning (HVAC) system for controlling the payload environment; adding two small storage rooms at the south end of the LSB; and increasing the capacity of the payload fuel and oxidizer loading systems.

The HVAC system supplies conditioned, low-pressure air or nitrogen to the launch vehicle and to internal systems of the payload. The existing HVAC equipment will be replaced with modern equipment with improved efficiency and reliability for supporting the Atlas II vehicles and their payloads. The new HVAC system will provide a class 100,000 clean-room, positive-pressure environment for the payload levels of the MST and comfort conditioned air to the rest of the MST. Three 125-ton cooling chillers, two operating and one standby, will provide cooling requirements for the system. These chillers will be located in the new Utility Building.

Two general storage rooms will be added to the east side of the LSB. Loading and emergency downloading systems for payload fuel and oxidizer will be located outside these rooms. There will be no long-term storage of fuel or oxidizer in these rooms, but at the time of loading, small amounts will be brought to the area along with portable loading equipment.

Additional tank capacity for liquid oxygen, hydrogen (for Centaur second stage), and helium systems for fueling will be installed, along with the associated control systems and piping. The Atlas II liquid oxygen requirements exceed the capacity of the existing storage and transfer system, so the existing system will be modified to include a new 45,000-gallon, rapid-load tank located immediately east of the existing SLC-3E oxidizer apron. The liquid hydrogen storage and transfer system will include a new 45,000-gallon storage tank. The tank, its associated vent skid and vaporizer will be located on the west side of the LSB, behind a natural berm. The area around the new tank, vent skid, and vaporizer will be paved with concrete, and the existing access road will be extended. A new 8-foot by 100-foot blast wall will be constructed on top of the existing berm to protect flight hardware from effects of an explosion in the vicinity of the liquid hydrogen storage tank. The liquid helium system will incorporate a new 5,000-gallon storage tank, located in an existing room in the LSB. Additional high-pressure helium storage vessels will be installed adjacent to the existing storage vessels to meet the requirements of Atlas II vehicles. A high pressure (6,000 psig) nitrogen gas pipeline may be extended to SLC-3E from an existing source near SLC-4. A new receiving station for nitrogen gas will be located on the west side of the LSB, adjacent to the new helium storage vessels. A new hydrogen gas flare will be installed for use during Centaur tanking, depressurization, or draining.

Launch Operations Building (Blockhouse, Bldg. 763)

Several modifications will be required to modernize the LOB (Bldg. 763); however, the extent of the modifications has not yet been determined. Minor technical improvements of the LOB, such as increasing power handling capacity, are currently planned to permit launches from SLC-3E to be controlled from the main Air Force Building on North VAFB via fiber-optic cable; however, the LOB (Bldg. 763) may continue to be the site of launch control for SLC-3E. If the LOB (Bldg. 763) is to be used, substantial electrical renovation and almost complete replacement of existing control consoles will be required. Several existing control consoles are virtually intact representations of electronic technology dating from the 1960s. Many of the consoles use magnetic meters rather than digital displays, and many use relays instead of computer controls. The external communication devices (telephones, black and white video monitors, switches, printers, and so forth) are clearly from and earlier technological era. If extensive renovations are undertaken to enable the LOB (Bldg. 763) to continue to serve as the control center for SLC-3E, then the appearance of the SLC-3E control room and, potentially, portions of the telemetry room will be changed significantly.

Associated Infrastructure

The infrastructure associated with SLC-3 comprises buildings that are not an integral part of the launch pads but that support pad activities. The complex infrastructure buildings within the SLC-3 perimeter fence include the Entry Control Point (Bldg. 768), storage sheds (Bldgs.

773 and 776), Pyrotechnic Shed (Bldg. 757), the Vehicle Support Building (Bldg. 766), the sewage treatment plant (Bldg. 769), and the Meteorological Shed (Bldg. 756). The SLC-3 Air Force Office (Bldg. 761), and the Technical Support Building (Bldg. 762/762A) are located immediately outside the perimeter fence but are also considered infrastructure associated with SLC-3.

A new utility building will be added to SLC-3 (fig. 6.1) to house two 500,000-Btu-per-hour natural gas-fired boilers, chillers, water treatment equipment, pumps, and related equipment. This building will be approximately 32 feet by 45 feet (1,440 square feet). The boiler system in the new utility building will be designed to provide the heating requirements for the SLC-3E HVAC system and sanitary hot water.

A new operations support building will be constructed (fig. 6.1). The operations support building will be located within the perimeter fence, near the front gate. Functions to be carried out in this new building will include communications, security, mission readiness, and payload integration. Although the Atlas II Program plans provide a 30,000-square-foot building, current planners are considering an 8,000-square-foot building.

A 7,000-square-foot addition to the Technical Support Building (Bldg. 762/762A) will provide additional administrative and engineering office space required to support SLC-3 launch activity. Construction design will be in character with the existing building.

The Entry control Point (Bldg. 768) will be either abandoned or demolished. A new 400-square-foot guardhouse will replace the Entry Control Point (Bldg. 768) functionally. A dilapidated traffic check house (Bldg. 759) near the interior fence around SLC-3E may be removed. No changes will be made to the other infrastructure buildings.

Additions and modifications of general support systems for SLC-3 also will be required. Additions to or improvements of the following systems are planned: electrical powerlines, an uninterruptable power system, a fire detection system, a fire suppression system, a vapor detection system, lighting systems, a facility grounding system, a technical grounding system, a Red/Black grounding system for elimination of high-frequency noise from critical launch systems, a cathodic protection system, a lightning protection system for SLC-3E, an electromagnetic interference system for SLC-3E, and a new MST vacuum system for SLC-3E. Many other items of equipment, both inside and outside buildings, will be added or replaced in conjunction with the major elements of the Atlas II reconfiguration. Part or all of the existing chain-link and barbed-wire perimeter fence surrounding SLC-3 will be replaced with a new security fence and a modern detection and deterrent system. The exact location of the new fence has not yet been determined, but the new fence generally will maintain or extend the existing boundaries of the secure area.

This documentation was prepared to mitigate effects of modification of SLC-3 on historic properties at SLC-3E. SLC-3W was documented in depth because of its similarity to and shared history with SLC-3E. The Atlas E/F program is scheduled to continue at SLC-3W until 1994, when the supply of these delivery vehicles is expected to be exhausted.

APPENDIX

Waterfall Diagram for Atlas 39E/NOAA-E
September 1984

	MONTH	SEPTEMBER																			
	C-DAY	10		11		12		13		14		17		18		19		20		21	
	SHIFT	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
	DESCRIPTION R-DAY	45		44		43		42		41		40		39		38		37		36	
01	PAD REFURBISHMENT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
02	PAD MISSION PECULIAR MOD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
03	FAIRING CLEANING	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
04	FAIRING ASSY								X	X	X	X	X	X	X	X	X	X	X	X	X
05	PU AGE CHECKOUT									X											
06	CRITICAL RESISTANCE CHECK WO/O PL											X	X	X							
07	LAUNCHER T/A											X	X	X	X						
08	MSL GRND POWER SENSOR ADJ															X					
09	PROPELLANT LOADING SYST T/A															X	X				
10	PNEU SYSTEM TURNAROUND																	X	X	X	
11	UMBILICAL MAST T/A																	X	X	X	
12	AUTOPILOT AGE C/O																	X	X	X	
13	AIRCONDITIONING SYS C/O																				X
14	RSC AGE C/O																				X
15	IMU/S-BAND PREP																				
16	LOGIC VALIDATION																				
17	BOOSTER ERECTION																				
18	SQUIB SIMULATOR CALIB																				
19	MATE AFT ADAPTER																				
20	UMBILICAL EJECT SYS C/O																				
21	PLCU C/O																				
22	BSTR SYS CHECK VALVE VERIF																				
23	B/O VALVE & D/P SWITCH C/O																				
24	PURGE & PRESSURIZE WAVEGUIDE																				
25	GUIDANCE WAVEGUIDE CALIBRATION																				
26	ABETS CALIBRATION																				
27	GUIDANCE CAN INSTALLATION																				
28	MATE FAIRING ASSY TO BOOSTER																				
29	STAGNG DISCONNECT C/O																				
30	PRESSURIZE GUID CANS																				
31	PYROTECHNICS C/O																				
32	BSTR ELEC CIRCUIT CHECKS																				
33	P/L UMBILICAL RETRACT C/O																				
34	PSC/TLM VSWR C/O																				
35	FEEDBACK TRANSDUCER INTEG TEST																				
36	TLM SYSTEM C/O																				
37	RSC CHECKOUT																				
38	A/B HYD FILL & BLEED (SHORT)																				
39	CRITICAL RESIST CHECK WITH PL																				
40	GUIDANCE C/O																				
	R-DAY	45		44		43		42		41		40		39		38		37		36	
	SHIFT	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20

	MONTH	SEPTEMBER										OCTOBER									
	C-DAY	24		25		26		27		29		1		2		3		4		5	
	SHIFT	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
DESCRIPTION	R-DAY	35		34		33		32		31		30		29		28		27		26	
01	PAD REFURBISHMENT																				
02	PAD MISSION PECULIAR MOD																				
03	FAIRING CLEANING																				
04	FAIRING ASSY																				
05	PU AGE CHECKOUT																				
06	CRITICAL RESISTANCE CHECK WO/O PL																				
07	LAUNCHER T/A																				
08	MSL GRND POWER SENSOR ADJ																				
09	PROPELLANT LOADING SYST T/A																				
10	PNEU SYSTEM TURNAROUND																				
11	UMBILICAL MAST T/A																				
12	AUTOPILOT AGE C/O																				
13	AIRCONDITIONING SYS C/O																				
14	RSC AGE C/O																				
15	IMU/S-BAND PREP	XXXX																			
16	LOGIC VALIDATION		XXXXXXXXXXXXXXXXXXXX																		
17	BOOSTER ERECTION						XXXX	MMMM	XXXXXXXXXX												
18	SQUIB SIMULATOR CALIB							XXXX													
19	MATE AFT ADAPTER								XXXXXXXXXX												
20	UMBILICAL EJECT SYS C/O								XXXXXXXXXXXXXX												
21	PLCU C/O										XXXX										
22	BSTR SYS CHECK VALVE VERIF										XXXX										
23	B/O VALVE & D/P SWITCH C/O										XXXXXXXXXX										
24	PURGE & PRESSURIZE WAVEGUIDE											XXXX									
25	GUIDANCE WAVEGUIDE CALIBRATION											XXXX									
26	ABETS CALIBRATION											XXXX									
27	GUIDANCE CAN INSTALLATION											XXXX									
28	MATE FAIRING ASSY TO BOOSTER											MMMMXXXXXXXXXXX									
29	STAGNG DISCONNECT C/O												XXXX								
30	PRESSURIZE GUID CANS													XXXX							
31	PYROTECHNICS C/O													XXXXXXXXXX							
32	BSTR ELEC CIRCUIT CHECKS													XXXXXXXXXX							
33	P/L UMBILICAL RETRACT C/O													XXXXXXXXXXXXXX							
34	PSC/TLM VSWR C/O														XXXX						
35	FEEDBACK TRANSDUCER INTEG TEST															XXXX					
36	TLM SYSTEM C/O															XXXX					
37	RSC CHECKOUT																XXXX				
38	A/B HYD FILL & BLEED (SHORT)																XXXXXXXXXX				
39	CRITICAL RESIST CHECK WITH PL																XXXXXXXXXX				
40	GUIDANCE C/O																	XXXX			
	R-DAY	35		34		33		32		31		30		29		28		27		26	
	SHIFT	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

	DESCRIPTION		SEPTEMBER					OCTOBER				
		MONTH	SEPTEMBER					OCTOBER				
		C-DAY	24	25	26	27	29	1	2	3	4	5
		SHIFT	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40
		R-DAY	35	34	33	32	31	30	29	28	27	26
41	AUTOPILOT SYSTEM C/O										XXXXXXXXXX	
42	DATA EVALUATION											XXXX
43	LN2 COLD FLOW C/O											XXXX
44	PRESSURIZATION CHANGEOVER											
45	PU CAN ACCEPTANCE TEST											
46	THRUST SECTION GN2 C/O											
47	AIRBORNE PNEUMATICS C/O											
48	PAYLOAD AGE INSTLN & C/O											
49	HYD FILL & BLEED (LONG)											
50	C-BAND BEACON C/O											
51	PROPULSION SYSTEM C/O											
52	PU SENSOR SYSTEM C/O											
53	PRESSURIZATION CHANGEOVER											
54	BSTR TANK DEWPOINT C/O											
55	PU SYSTEM C/O											
56	PRODUCT REVIEW TEAM											
57	FAIRING ORDNANCE C/O											
58	BOOSTER SIMFLIGHT											
59	SQUIB SIMULATOR VERIFY											
60	DATA EVALUATION											
61	DEMATE FAIRING ASSY											
62	WET DRESS REHEARSAL PREPS											
63	COMMIT TEST											
64	DISASSEMBLE FAIRING											
65	MATE S/C TO CONICAL ADAPTER 1610											
66	WET DRESS REHEARSAL											
67	ENCAPSULATE 1610											
68	WDR SECURE											
69	DATA EVALUATION											
70	BOOSTER LAUNCH PREPS											
71	S/C ALIVENESS TEST-PCA											
72	SYSTEM SAMPLING											
73	TRANSPORT PREPS 1610											
74	BATTERY ACTIVATION											
75	TRANSPORT & MATE PAYLOAD											
76	APOGY KICK MOTOR ARM & SAFE											
77	BUOLVA DEST FUNCT C/O											
78	FLIGHT READINESS TEST											
79	SPACECRAFT READINESS TEST											
80	FAIRING ORD INSTLN & CONNECT											
81	AUTOPILOT READINESS											
		R-DAY	35	34	33	32	31	30	29	28	27	26
		SHIFT	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40

	MONTH	OCTOBER																			
	C-DAY	8		9		10		11		11		12		15		16		17		18	
	SHIFT	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	DESCRIPTION R-DAY	25		24		23		22		21		20		19		18		17		16	
41	AUTOPILOT SYSTEM C/D																				
42	DATA EVALUATION																				
43	LN2 COLD FLOW C/O																				
44	PRESSURIZATION CHANGEOVER	XX	XX																		
45	PU CAN ACCEPTANCE TEST	XXXX																			
46	THRUST SECTION GN2 C/O	XXXX																			
47	AIRBORNE PNEUMATICS C/O	XXXXXXXXX																			
48	PAYLOAD AGE INSTLN & C/O	XXXX		XXXX		XXXX		XXXX													
49	HYD FILL & BLEED (LONG)			XXXXXXXXXX																	
50	C-BAND BEACON C/O					XXXXXXXXXX															
51	PROPULSION SYSTEM C/O					XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							XXXX		XXXX		XXXXXXXXXXXXXX				
52	PU SENSOR SYSTEM C/O							XXXX													
53	PRESSURIZATION CHANGEOVER									XX	XX										
54	BSTR TANK DEWPOINT C/O											XXXX									
55	PU SYSTEM C/O											XXXX									
56	PRODUCT REVIEW TEAM											XXXX		XXXX		XXXX		XXXX			
57	FAIRING ORDNANCE C/O																	XXXX			
58	BOOSTER SIMFLIGHT																			[illegible]	
59	SQUIB SIMULATOR VERIFY																				XXXX
60	DATA EVALUATION																				XXXXX
61	DEMATE FAIRING ASSY																				
62	WET DRESS REHEARSAL PREPS																				
63	COMMIT TEST																				
64	DISASSEMBLE FAIRING																				
65	MATE S/C TO CONICAL ADAPTER 1610																				
66	WET DRESS REHEARSAL																				
67	ENCAPSULATE 161D																				
68	WDR SECURE																				
69	DATA EVALUATION																				
70	BOOSTER LAUNCH PREPS																				
71	S/C ALIVENESS TEST-PCA																				
72	SYSTEM SAMPLING																				
73	TRANSPORT PREPS 161D																				
74	BATTERY ACTIVATION																				
75	TRANSPORT & MATE PAYLOAD																				
76	APOGY KICK MOTOR ARM & SAFE																				
77	BUOLVA DEST FUNCT C/O																				
78	FLIGHT READINESS TEST																				
79	SPACECRAFT READINESS TEST																				
80	FAIRING ORD INSTLN & CONNECT																				
81	AUTOPILOT READINESS																				
	R-DAY	25		24		23		22		21		20		19		18		17		16	
	SHIFT	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

	MONTH	OCTOBER																				
	C-DAY	22	23	24	25	26	29	30	31	01	02	03	04	05	06	07	08					
	SHIFT	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
	DESCRIPTION R-DAY	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00					
41	AUTOPILOT SYSTEM C/O																					
42	DATA EVALUATION																					
43	LN2 COLD FLOW C/O																					
44	PRESSURIZATION CHANGEOVER																					
45	PU CAN ACCEPTANCE TEST																					
46	THRUST SECTION GN2 C/O																					
47	AIRBORNE PNEUMATICS C/O																					
48	PAYLOAD AGE INSTLN & C/O																					
49	HYD FILL & BLEED (LONG)																					
50	C-BAND BEACON C/O																					
51	PROPULSION SYSTEM C/O																					
52	PU SENSOR SYSTEM C/O																					
53	PRESSURIZATION CHANGEOVER																					
54	BSTR TANK DEWPOINT C/O																					
55	PU SYSTEM C/O																					
56	PRODUCT REVIEW TEAM																					
57	FAIRING ORDNANCE C/O																					
58	BOOSTER SIMFLIGHT																					
59	SQUIB SIMULATOR VERIFY																					
60	DATA EVALUATION	XXXX																				
61	DEMATE FAIRING ASSY		XXXX																			
62	WET DRESS REHEARSAL PREPS		XXXXXXXXX																			
63	COMMIT TEST			XXXX																		
64	DISASSEMBLE FAIRING			XXXX																		
65	MATE S/C TO CONICAL ADAPTER 1610				XXXX																	
66	WET DRESS REHEARSAL				MMMM																	
67	ENCAPSULATE 1610					XXXX																
68	WDR SECURE					XXXXXXXXX																
69	DATA EVALUATION					XXXXXXXXXXXXXXXXXX																
70	BOOSTER LAUNCH PREPS					XXXXXXXXXXXXXXXXXXXXXXXXXXX							XXXXXXXXXXXXXXXXXXX									
71	S/C ALIVENESS TEST-PCA						PPPP			PPPP												
72	SYSTEM SAMPLING						XXXXXXXXX															
73	TRANSPORT PREPS 1610							XXXX														
74	BATTERY ACTIVATION							XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX														
75	TRANSPORT & MATE PAYLOAD							XXXXMMMM														
76	APOGY KICK MOTOR ARM & SAFE									XX												
77	BUOLVA DEST FUNCT C/O									XXXX												
78	FLIGHT READINESS TEST											XXXX										
79	SPACECRAFT READINESS TEST											XXXX										
80	FAIRING ORD INSTLN & CONNECT												XXXXXXXXXXXXXX									
81	AUTOPILOT READINESS													XXXX								
	R-DAY	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00					
	SHIFT	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81

		MONTH	OCTOBER																				
		C-OAY	22	23	24	25	26	29	30	31	01	02	03	04	05	06	07	08					
		SHIFT	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
	OESCRIPTION	R-OAY	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00					
82	FAIRING PYRO VERIFICATION														XXXX								
83	GUIDANCE CHECKOUT															XXXX							
84	RSC C/O																XXXX						
85	SPACECRAFT ARMING																	XXXXXX					
86	LAUNCH																	MMMM					
87	LAUNCH SECURE																		XXXX				
		R-OAY	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00					
		SHIFT	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81